VOLUME LIII NUMBER 5 WHOLE 466

SCHOOL SCIENCE AND MATHEMATICS

MAY 1953

UNIVERSITY OF MICHIGAN LIBRARIES

School Science and Mathematics

A Journal for All Science and Mathematics Teachers

All matter for publication, including books for review, should be addressed to the editor. Payments and all matter relating to subscriptions, change of address, etc. should be sent to the business manager.

Entered as second class matter December 8, 1932, at Menasha, Wisconsin, under the Act of March 3, 1879. Published Monthly except July, August and September at 450 Ahnaip St., Menasha, Wis. PRICE. Four dollars and fifty cents a year; foreign countries $5.00; current single copies 75 cents.

Contents of previous issues may be found in the Educational Index to Periodicals.

Copyright 1953, by the Central Association of Science and Mathematics Teachers, Inc.
Printed in the United States of America

GLEN W. WARNER
Editor
Lakeville, Indiana

RAY C. SOLIDAY
Business Manager
Box 408, Oak Park, Ill.

DEPARTMENTAL EDITORS

BIOLOGY—John E. Potzger
Butler University, Indianapolis, Ind.
Joseph P. McMenamin
Oak Park-River Forest High School, Oak Park, Ill.
Nelson L. Lowry
Arlington Heights High School, Arlington Heights, Ill.

CHEMISTRY—Gerald Osborn
Western Michigan College of Education, Kalamazoo, Mich.
Allen F. Meyer
Mackenzie High School, Detroit, Mich.

ELEMENTARY SCIENCE—Milton O. Pella
The University of Wisconsin, Madison, Wis.

GENERAL SCIENCE—John D. Woolever
Mumford High School, Detroit, Mich.

GEOGRAPHY—Villa B. Smith
John Jay High School, Cleveland, Ohio

MATHEMATICS—Cecil B. Read
University of Wichita, Wichita, Kan.
George E. Hawkins
Lyons Twp. High School and Junior College, La-Grange, Ill.

MATHEMATICS PROBLEMS—G. H. Jamison
State Teachers College, Kirksville, Mo.

NATURE STUDY—E. Laurence Palmer
Cornell University, Ithaca, N.Y. and The American Nature Association.

PHYSICS—Julius Sumner Miller
West Los Angeles 25, Cal.
E. Wayne Gross
R.R. 6, Bloomington, Ind.

Turtox Sets of Kodachrome Lantern Slides

These sets consist of our very best Kodachromes—the cream of thousands of slides—at prices which offer you substantial savings. Available are slides of Fungi, Ferns, Flowers, Tropical Plants, Fruits and Seeds, Sea Shore Life, Insects, Frogs, Snakes, Birds and Mammals.

Write for descriptive list.

TURTOX PRODUCTS

GENERAL BIOLOGICAL SUPPLY HOUSE
Incorporated
761-763 EAST SIXTY-NINTH PLACE
CHICAGO 37, ILLINOIS
The Sign of the Turtox Pledges Absolute Satisfaction

The word "Professor" becomes a synonym for "queerness." The university faculty becomes anything but a brotherhood and the disciples of each cult become slave-memorizers and slave-dispensers.

"The Science Janus"—WILLIAM GOULD VINAL.

CONTENTS FOR MAY, 1953

Science at Work. A Unit in General Science—*Maitland P. Simmons* 339

Remarks on the Conservation of Mass-Energy—*Julius Sumner Miller* ... 344

The Science Janus—*William Gould Vinal* 345

Rome's Contributions to Natural Science—*A. Postl* 358

Some Techniques of a Conservation Tour—*Raymond Kienholz* 363

On the Scientific Method—*Charles A. Compton* 372

The Place of Mathematics in Secondary Education—*William David Reeve*. 375

Regions of Vulcanism—*James K. Anthony* 387

Visual Aids for Teaching Chemical Industrial Processes—*A. A. Himmel*.. 397

Eastern Association of Physics Teachers. One Hundred Eighty-Fifth Meeting—*Albert R. Clish, Secretary* 399

Eastern Association of Physics Teachers. One Hundred Eighty-Sixth Meeting—*Albert R. Clish, Secretary* 402

Problem Department—*G. H. Jamison* 411

Books and Pamphlets Received 416

Book Reviews 418

School Science and Mathematics

We Cover the Earth

Is read by subscribers in every state of the Union, all provinces of Canada, and thirty-three foreign countries.
It is owned by teachers, managed by teachers, and edited by teachers.
It comes to your desk every school month.

Interesting Articles in Volume 52

Science and International Understanding—Teaching for Appreciation of Mathematics—Our Heritage, the Land—Education, the Primary Atomic Control—Tales of Tall Timber—Foundations, Industry and Education—An appreciation of Bos Indicus—Isle Royale, the Wilderness Paradise—School Forests, Outdoor Laboratories for Schools—Historically Speaking, A Playlet—Greenland, Artic Wonderland—An Experiment in the Integration of Mathematics and Science—The Significance of Number—Science Education and World Understanding—Static Charges on the Ends of a Moving Conductor—Elementary Teaching Hints—The Contribution of Arithmetic to the Study of Geography—Corrosion, the Great Destroyer of Metals.

Helpful Reprints and Supplements

Atomic Energy: A Science Assembly Lecture, illustrated	.25
Mock Trial of B versus A—A play for the Mathematics Club	.30
100 Topics in Mathematics—for Programs or Recreation	.25
Poison War Gases	.20
New Emphases in Mathematical Education, with bibliographies, 1949	.25
Popular Mathematics: Bibliography	.20
Mathematics Problems From Atomic Science	.25
The Mathematics of Gambling	.25
Computations With Approximate Numbers	.25
The Radical Dream—A Mathematical Play for Puppets	.20
Geometry Theorems: A List of Fundamentals	.20
How Water Serves Man. A teaching unit	.20
Biology Reading List	.20
Won by a Nose. A chemistry play	.25
Some War-Time Developments in Chemistry—48 pp.	.50
Radioactive Isotopes: A Science Assembly Lecture, illustrated	.25
Kem: Two Games for Chemistry Classes	.15
Modern Periodic Arrangements of the Elements; illustrated	.25
Ion Visits the Realm of Air. A Play	.25
The King of Plants. A play for science clubs	.25
Three Families of Great Scientists: dramatized	.30
Some Lessons About Bees. A 32-page booklet; illustrated	.20
The Triumph of Science. A play for auditorium programs	.25
In a Sound Studio. A play: Physics and Music	.25
In Quest of Truth. A play in two parts	.25
A Student's Approach to Mechanics	.25
Youth Looks at Cancer. A biology play	.25
Laboratory Work in Single Periods: Method	.15
Apparatus for Demonstrating the Fundamentals of Radio	.20
Youth Opens the Door to Cancer Control, bibliographies, 1949	.25
Science in the Grades: Practical Contributions—35 pp.	.30
Extracting Aluminum. A one act chemistry play	.15
Vitalizing Chemistry Teaching. A Unit on the Halogens	.15
Telescope Making Illustrated	.25
A Scientific Assembly Program, Wonders of Science	.30
What Is Scientific Method?	.20
Elementary School Science Library	.20
Projection Demonstrations in General Science	.20
Atomic Energy—A Play in Three Scenes	.30
Motion Pictures for Elementary Science (1949)	.25

Orders for Reprints must be prepaid.

SCHOOL SCIENCE AND MATHEMATICS

Price $4.50—Foreign $5.00

No numbers published for July, August and September

P.O. Box 408 Oak Park, Ill.

SCHOOL SCIENCE
AND
MATHEMATICS

VOL. LIII | MAY, 1953 | WHOLE NO. 466

SCIENCE AT WORK

A UNIT IN GENERAL SCIENCE

MAITLAND P. SIMMONS
Irvington High School, Irvington 11, New Jersey

Most educators today agree that a purposeful "doing" program is conducive to better learning. This is especially true for young people at the junior high school level. General science perhaps more than any other subject lends itself readily to this type of active learning. If one is to initiate a well-executed program of this sort for the year, more attention should be given to the selection, classification, arrangement, and organization of the choice activities.[1] They must be workable, easy to perform, satisfying, and worthwhile to the student. These characteristics are illustrated in the following.

The organized activity begins with the Introduction—a set of carefully planned questions which develops a deeper appreciation of the scientific world. Futhermore, and this is extremely important, these questions probe the student's experience and arouse his curiosity in the experiment to be performed.

Next comes the Directions for Study—what to do in performing the meaningful enterprise. The materials used are simple, inexpensive, and easily obtained. It is highly desirable that pupils and teachers work together when performing the experiment. This is followed by Observations from Study—questions which focus attention on the significant aspects of the activity. For effective results, the students should be encouraged to make neat sketches, record data, and inter-

[1] Simmons, Maitland P. *The Young Scientist.* New York: Exposition Press, Inc., 1951. The book contains 35 ninth-grade general science classroom activities with functional and instructive illustrations. (See reviews in *The Science Teacher,* October, 1951. *The Clearing House,* January, 1952. SCHOOL SCIENCE AND MATHEMATICS, February, 1952.)

UNIVERSITY OF MICHIGAN LIBRARIES

pret the findings independently in their individual booklets. The work should be held to a high standard of accuracy, but, on the other hand, should allow for originality of expression. Last comes the Interpretations—another set of well-chosen questions which make young people relate the guided activity to other happenings they know about, stimulating their new knowledge in interpreting the phenomena of everyday life, and finally to encourage them into further experiments. Below is the suggested technique for creating and sustaining the interest of these students.

UNIT: MACHINES

Topic Study: Simple Machines

Introduction

1. Describe how the American colonists made the nails they used in building their homes, when they had no suitable iron for making nails. How did they hold their household building materials together?
2. In your opinion, what was man's first useful tool?
3. What machines were used in the construction of the Great Pyramids of Egypt?
4. Describe the types of machines used in warfare by the Romans and the Crusaders.
5. Explain why the Bronze Age came before the Iron Age.
6. Write a composition on the life of Archimedes and his mechanical inventions. How did the city of Syracuse use some of them?
7. Name some machines invented during your grandfather's boyhood. Give the inventor of each. Were they simple machines? Why?
8. Define a lever. How is it useful to us in doing work? Name the different parts. (See Fig. 1.)
9. How is a small force used to overcome a large one? Give an example. (See Fig. 1.)
10. Classify the following machines: bicycle, screw driver, chisel, pulley, golf club, grindstone, and pocketknife.
11. How would you hold a piece of stiff cardboard in order to cut it with a pair of scissors? Explain.
12. When loading stones into a wheelbarrow, it is advisable to put them as near to the wheel as possible. Explain.
13. Why will a strong wind cause an umbrella to turn inside out?
14. Illustrate, by means of a poster, the simple machines in the human body.
15. Assemble for comparison the following special types of scissors: manicure scissors, paper-hanger's scissors, pruning scissors, hedge

shears, paper shears, sheep shears, carpet shears, and barber's clippers. Which has the greatest leverage? Why?

16. Make a list of simple machines seen in your schoolroom, in your home, and at some amusement park.

17. Suggest some measurement levers.

18. How many labor saving devices (simple and complex machines) can you name? Describe them. How have they affected child labor?

19. Discuss this question: Is it necessary for girls to have a knowledge of machines?

20. At what place in the door, the latch or the hinge, is your finger more likely to be crushed? Why?

21. A boy working on a piece of hardwood wishes to pull out a nail with a claw hammer: therefore, he puts a piece of wood under the head of hammer. What is his reason?

22. Why does a plumber use a long handle wrench to unscrew rusted pipes?

Interpretations

1. Why does a person often use pliers to pick up very small objects?

2. Where should the hinges on a gate be placed, close together or far apart? Why?

3. Which would you prefer for obtaining water from a well, a bucket with a rope, or a pump? Which would be easier to operate, a long handle or a short handle pump? Why?

4. Name two machines which may be classified as modified levers.

5. Explain the ways in which levers differ as to the position of the effort, the fulcrum, and the resistance. (See Fig. 1.)

6. Is it possible for a man with a claw hammer to exert a pull of one-half a ton? Why?

7. Study the parts of a sewing machine, washing machine, meat grinder, and automobile jack. With the aid of sketches explain the simple machines involved.

8. List five labor-saving devices commonly used in the home, in the factory, and on the farm, Beside each, explain the method of doing work before the device was invented.

9. Why is it impossible to invent a perpetual motion machine? Explain.

10. Compare the advantages with the disadvantages that machines have brought into civilization. How has the invention of so many machines affected employment? Suggest a needed invention.

11. Why are men continually inventing new machines?

12. What advantage is a long bat in baseball?

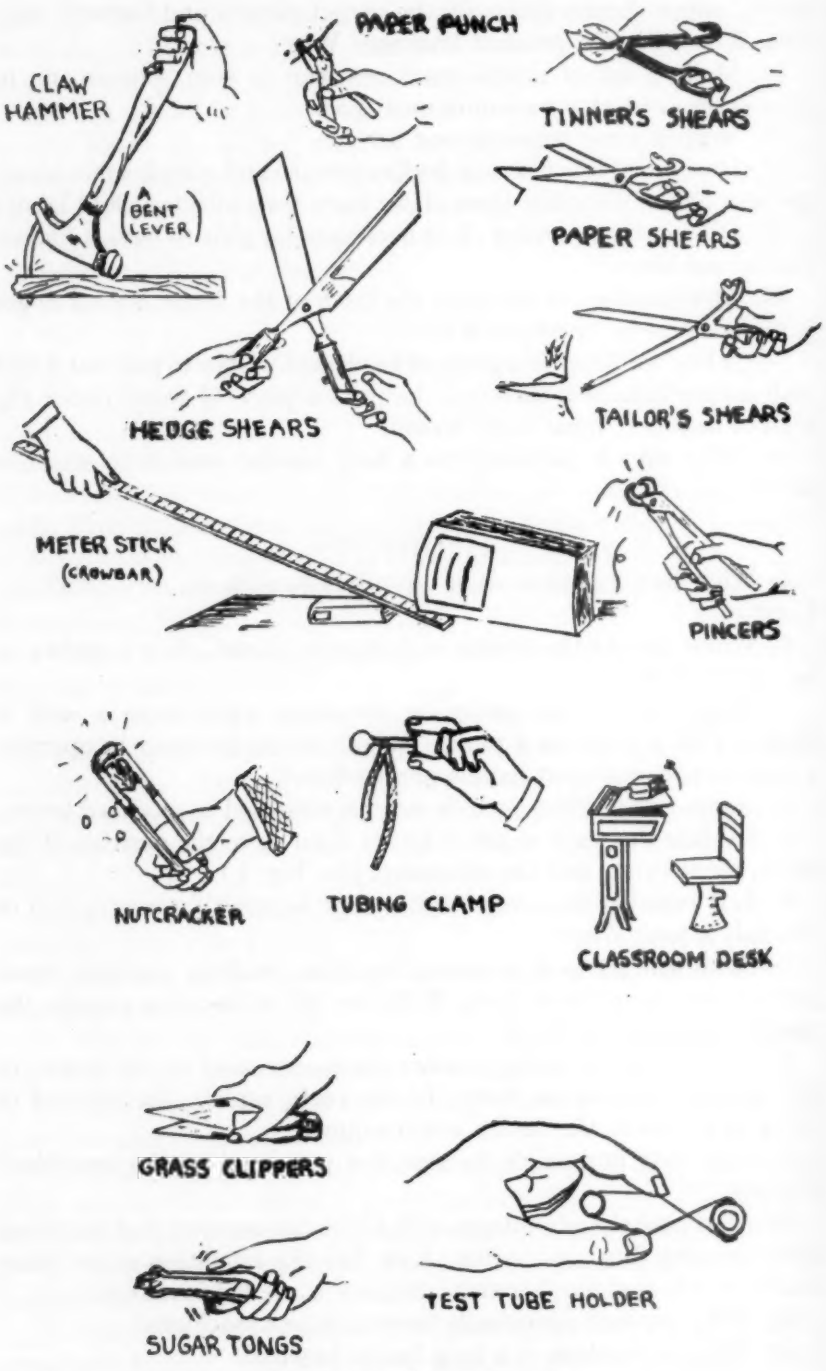


FIG. 1. Some levers at work.

13. When you are sweeping a floor, do both hands do the same amount of work? Explain.

14. Suppose you knew your own weight but not that of your companion, explain how you could find his weight by means of a teeter board and a ruler.

15. Explain how a window awning is raised.

16. A tall man and a short man each carry the same load in a wheelbarrow. Which is doing more work? Explain.

17. The driver of a heavy truck discovers a flat tire. He has a 10-foot pole in the truck and he can use a nearby rock for a fulcrum. Explain how he can raise the truck by using his pole as a lever.

18. If two boys of the same weight are on a seesaw, where should they sit to balance it? Suppose one boy weighs less than the other, where should he sit? Which boy would go higher on the seesaw? Would they both move up and down at the same rate of speed? Explain.

19. If John sits 6 feet from the middle of the seesaw and Henry sits 5 feet from the middle, the seesaw will balance evenly. John weighs 90 pounds. How much does Henry weigh?

20. A 95-pound boy balances his younger brother who weighs 55 pounds and sits 8 feet from the fulcrum of a seesaw. How far from the center does the older brother have to sit to balance the seesaw?

21. Would it be possible for a boy weighing 65 pounds to move a stone weighing 310 pounds with a 6-foot lever? Describe the procedure by making a diagram showing the position of the boy, the stone, and the fulcrum.

22. Make a sketch to show where a 10-pound weight should be suspended on a yardstick to balance a 20-pound weight 5 inches from the fulcrum.

NEW EDUCATIONAL DIRECTORY

Listed in this directory are 1,889 institutions of higher education reported to the Office of Education as being in operation during 1951-52, offering at least a 2-year program of college-level studies, and meeting the following criteria:

1. Institutions accredited or approved by a recognized Nation-wide, State, regional, or professional agency, or operating under State control.

2. Institutions not meeting requirements of criterion 1 are eligible for inclusion if their credits are accepted unconditionally (at full value) by not less than three fully accredited institutions.

Higher Education gives the accreditation, control, student body, classification of institution by level of offering and type of program, enrollment, and names of principal administrative officers in institutions of higher education.

EDUCATION DIRECTORY 1952–53—PART 3, HIGHER EDUCATION. By Theresa Wilkins, Office of Education. 178 pages. 1952. For Sale by the Superintendent of Documents, U. S. Goverment Printing Office, Washington 25, D. C. 45 cents.

UNIVERSITY OF MONTANA LIBRARIES

REMARKS ON THE CONSERVATION OF MASS-ENERGY

JULIUS SUMNER MILLER
Ford Foundation Fellow, University of California

In a recent discussion with a professor of philosophy the problem of entropy arose. This is a classical inquiry and leads to the conjecture on whether or not the Universe is running down. Are we headed for a *cold* death? On classical grounds it does appear that the entropy of our system is increasing. By this we mean that the *unavailability* of energy is increasing. Indeed, it appears that the entropy of a system can go but one way—toward more. In general, energy is available *first* in the form of stuff, that is, matter. If matter is constantly undergoing annihilation then *available* energy *is* becoming less. It is well established that the processes in the Sun lead to the "destruction" of some four million tons of matter per second. The Sun *is* running down. If the process is all one way—that is, *from* matter *to* energy—the conclusion is inescapable. Our system *is* running downhill. Now with a little daring I propose a way out of this:

Consider the Universe a *closed* system. This is a valid point of departure. Let it be finite *and bounded*. This departs a bit from Einstein's universe—finite yet unbounded, but a safe conjecture, nonetheless. Let the ENERGY content of this closed system be fixed. There is no *leaking* anywhere. If matter is going into energy—like material stuff going into radiant energy, say—we are met with a paradox. This *mass-to-energy* transformation is pretty well established. It obeys the law $E=mc^2$. To hold our energy content *fixed* let some E go into m by the transformaation $m=E/c^2$. I suggest that *matter is being born*. The total number of "particles" in the Universe is thereby fixed, and the average universe-*density* is unaltered.

PROFESSOR REEVE HONORED

(The following release did not reach us until after our preceding issue went to press but we include it here because of the very general interest.)

The Regents of the University of Minnesota, upon unanimous recommendation of the Faculty Committee on Honors, and the Administrative Committee of the Senate, have voted to present to William David Reeve, Professor Emeritus of Mathematics at Teachers College, Columbia University, New York City, "The Outstanding Achievement Award of the University, which is reserved for former students of the institution who have attained high eminence and distinction."

The award will be presented on the evening of March 31, 1953, at a dinner in the Main Ballroom of the Coffman Memorial Building on the occasion of the dedication of the new College of Education Building on the Minnesota campus.

The audience that evening will be made up of University of Minnesota staff members, member of the Minnesota State Legislature, and Minnesota educators who will be on the campus in connection with Schoolmen's Week.

Professor Reeve was for many years head of the department of mathematics and principal of the University of Minnesota High School, until he went to Teachers College in 1923. He graduated from the State Teachers College at Terre Haute, Indiana in 1907, and from the University of Chicago in 1909, where he taught mathematics in the University High School from 1910 to 1915, when he went to the University of Minnesota. Before he went to the University of Chicago, he taught six years in the public schools of Indiana.

Professor Reeve was editor of *The Mathematics Teacher*, the official journal of the National Council of Teachers of Mathematics, from 1928 to 1950, and editor of nineteen of the twenty-one National Council Yearbooks on Mathematics. He is an honorary member of the Mathematical Association of Great Britain, and the Central Association of Science and Mathematics Teachers.

THE SCIENCE JANUS

WILLIAM GOULD VINAL, "Cap'n Bill"
Emeritus Professor Nature Education, University of Massachusetts, Boston, Mass.

A dichotomy of interests exists in all university science departments and professional schools. There are horn-rimmed specialists and departed generalists. The problem is that that part of the college student's *whole education*, which looks to his science of life as a responsible human being and citizen, is neglected. This paper has to do with the retrospect of an "unholy" generalist.

Many questions might be posed to talented science specialists regarding the proper balance between the trend toward specialization and apparent generalization needs.

Is this an epoch of exploitation of natural resources or the use of the earth's resources for the good of all the citizens of the world?

What part should scientists play in the race between the accumulation of knowledge and the moral use of knowledge?

Are scientists so preoccupied with the minute and invisible that they neglect the whole and the visible?

How much truth is there to the concept that the "West" deals with the goodness of life in the realm of the spirit and only communists are the crass materialists who accomplish by death, or slavery, which is worse than death?

Should we, as biologists, emphasize interdependence more than struggle for existence? Should we measure the individual as well as the group? Should we evaluate brains as well as brawn? Should we preach that nature is more concerned with subsistence than with subjugation? Does specialization in the plant and animal world destroy unity?

In the beginning God created the heaven and earth and the fulness thereof. Man has dominion over many things. Man the scientist, has many responsibilities.

Originally, the individual who dealt with animals, plants, minerals, and other natural objects, was called a natural philosopher and the subject was known as natural history. Later the study was restricted to a study of plants and animals. Tracing man's dealings with nature through the centuries is interesting.

The Heidelberg man was a naturalist by necessity. The Greek naturalist Aristotle, in the Fourth Century B.C., began to make recordings on papyrus. Adam and Noah had their troubles, for no creature had a real name. Plato's quill wrote "featherless biped" instead of *Homo sapiens*. Linnaeus's *Systema Naturae* (1758) brought a vocabulary relief. In the Nineteenth Century A.D. there were such generalists as Agassiz, Audubon, Darwin and Thoreau. In the Twentieth Century there were Burroughs, Fabre, Theodore Roosevelt, and David Starr Jordan. Then, ***modern*** (?) ***science*** was born. The general naturalist was outnumbered by the specialist. The

UNIVERSITY OF MICHIGAN LIBRARIES

generalist, within academic walls, disappeared with the passenger pigeon.

Change is a biological law. It not only changes ladies hats, modes of transportation, and automobile models, but fashions in natural history. Within a life time there has been moral natural history such as the industrious hen and busy bee; species hunting; evolution with the upsetting idea of man descending from monkey, desiccated and upholstered specimens for the cabinet; closet natural history with tedious hours of peering through microscopes and making outline drawings; dissecting earthworms and cats; cultures of bacteria; biochemistry; and now physical biology. There is the old squib about learning more and more about less and less or, to put it another way, less and less about more and more.

Biologists not only went into the narrowing process but built all kinds of imaginary fences. Some zoologists thought that there was no legitimate area for research in taxonomy. There were the schools of purists and applied scientists. The amateur was scorned by the professional. While the elite were laboring with *species intelligibilis impressa*, Thoreau was pioneering with ecology and conservation about Walden Pond. No less a man than Agassiz, as well as neighbors and transcendentalists, consulted him as sane and practical. After a century his *Journals* are being quoted by such literateurs as Edwin Way Teale. Aldo Leopold ranked Thoreau as the "Father of American Phenology." Henry D. Thoreau was a generalist.

Today's investigators are geophysicists, biophysicists, isotopists, and so on, ad infinitum. There are dependable interpreters. Unfortunately, there are also jazzer-uppers, Stalinized cadres for scientists; and super-eccentrics of all kinds without social responsibilities. Each specialist has his own jargon which has to be translated for other specialists to understand. This terminology has become astronomic. The farther a specialist goes up the channel, the deeper the canyon, until the last thing he can conceive is how the canyon was made. The word "Professor" becomes a synonym for "queerness." The university faculty becomes anything but a brotherhood and the disciples of each cult become slave-memorizers and slave-dispensers. As purveyor of facts, each keeps his discoveries in the cloister, or at least never allows them to get out of hand in anything more then in code in a highly technical journal, *The Koran*. Every university has one or more prize exhibits of ignorant-narrowness. Sometimes they are harbored on the basis of "Let us honor our distinguished, unalloyed workers." When certain parasites went in for specialization in specific hosts the biologist decreed that they were degenerates. Such "sieving" evidently does not always apply to humans who may be practicing isolationism.

There are two horns to the dilemma. The horn that produced generalists has become vestigial. The horn that produces specialists often proliferates with attendant ulcers. Let's examine this two-headed Janus more closely.

One would be naive to think that we do not need specialists. Our very survival depends on specialists. The splitting of the atom can bring a new order or chaos. Frédéric and Irène Joliot-Curie are well-known atom scientists. Both won a Nobel prize in chemistry in 1935. At the same time both are communists. As such they condone Lamarkian-Russian principles which are no longer supported by geneticists. They compare Karl Marx, as a student of human history to Charles Darwin, the student of biological change. Both Marx and Darwin were concerned with struggle for survival. The communists refer to slaves, wage slaves, and a classless society. If communists take an anti-communist oath it is futile. To *Lie* is admittedly a communist technique. To tell the *Truth* is a scientific aim. How can we put teeth into our brand of science to protect us against insiduous lying?

Fortunately for us there are specialists who are not fascists, Nazis, or communists. Hitler rejected the great German research workers Dr. Albert Einstein and Dr. Lise Meitner because they were "non-Aryan." Dr. Niels Bohr, who taught at Copenhagen University was handed $40,000 for research on the atom by the Rockefeller International Education Board. He was forced out of the Bund by the Nazis. Enrico Fermi, physicist at the University of Rome, left Italy to continue work at Columbia University. Kjell Nielsen, the chemical engineer, camped in a ski-hut for four months on one month's rations, to blow up an atomic factory in the stillness of an Arctic night. Specialists can be jarred into responsibility for freedom of the individual and responsibility for the ordinary citizen.

We have seen that atom scientists can become either communists or liberators. Specialists can also be credited with concentration camps and machines of death. The Nazis demonstrated that it did not pay to purge the "superior" race. There is evidence that the communists have not learned "the lesson." Frankly, I am scared when I see the narrowness of some specialists, when I see corrupt government leaders, when I read about desperate labor tycoons, and the Alger Hisses of the brain-trust. We live in a world of atomic bombs that has not accepted the Golden Rule. The Russians have completely purged all Mendelist-Morganists from Universities. They are purging Soviet-education of Jews. It is with reluctance that Tito comes to our side. There is little comfort in the thought that we must outpace the Russians as we did the Germans. The chit-chat in a communistic society about "objectivism" which is condemned and

UNIVERSITY OF MICHIGAN LIBRARIES

objective science which is permissible, the collective farm and the collectivization of the sciences, and the abolishing of the qualitative differences between natural and social sciences should be clarified in the minds of future scientists.

Those specialists who would not have generalists is something like the ostrich with his head in the sand. It would be ludicrous to send a bio-chemist, who has been in an ivory tower all his life to be high commissioner in Germany. Dr. James Bryant Conant, the generalist, was the head of his alma mater's chemistry department before becoming president of the oldest university, Harvard, in 1933. Conant, Chairman of one of our newest scientific organizations, the National Science Foundation, in World War II was Chairman of the National Defense Research Committee. He was head of the research program to develop chemical warfare, nuclear fission, radar, and anti-radar. Having served as intermediary for scientists, generals, and industrialists he is selected because of his adeptness in science and human welfare. There are few citizens in the Western bloc who do not wish him well in his mission.

Admittedly, citizens do not have to have a science course to drive a car, to benefit by TV, to buy tooth paste, to get weather predictions, to purchase finger nail polish, to take thyroid pills, or to use a camera. Citizens do not have to experience the laboratory to be thankful that the Germans did not get the atomic bomb. The work on the atomic bomb was so specialized that few knew what they were producing. That science, the military, industry, and labor could work so efficiently together was the greatest achievement in history. Humans can work together constructively without fear or hate.

There are other things that all citizens of a democracy must know. We should recognize mass psychology and mass hysteria. We should know when we are attacked by a propaganda of lies, the truth of advertising claims (Whether it is chlorophyll or copper in the tooth paste); and the habits of the clothes moth. We should recognize that the antivivisection "cell" is both emotional and dictatorial. We should know the policy of the U.S. and the U.N.O.; the methods of science; the meaning of international trade barriers; and the need of conservation. We should know something about the deterministic role of the natural environment; population pressure; land use planning; transportation to market; water sheds; wildlife; insects; disease; and recreation. We should know that playing with Chinese firecrackers and joining with the Chinese for new social responsibilities are quite different. The layman has the right to know what scientists discover, such as the atomic bomb. What the shooting in Korea is about? Why the "worms" on Bikini are important? Why the utility of an auto is not dependent on chrome trim? Why landless peasants

should have land. Why individual high school youngsters can discover? Why people, as well as wildlife, need sanctuaries? Laymen must change their ways of thinking.

Scientists must also change their way of thinking. Science is as dependent on community votes as it is on philanthropy. Science can be aesthetic as well as precise. Science wins peace as well as wars. Although science is reason based on facts, there are scientists who can be fanciful, even emotional. Some scientists are liars. Some scientists produce great music, great art, and great literature. Science is judged by its inner spirit as well as by its physical manifestations. Scientists who are informed and honest, and most of them are, are practitioners of open-mindedness and focused adaptability.

There are, however, cloistered pedants who are so absorbed with professional privileges for the intelligentsia, academic heraldry, and systematic procedure from cell to cell, or frog to fish to reptile, that they have no time for the proletariat. An example at hand is the typical freshman science course. It has extraordinary homogeneity, really to the danger point of provincialism. The emphasis is on enclycopedic knowledge rather than frontiers, principles, freedom of thought, or action. The student is expected to quote biology rather than to think biology. He is force-fed phylogenetic sequence which again and again will become academic fare. Out of this flock, by accident or by association, unsuspecting but potential specialists in science, are indoctrinated in a limited field. They do not even have an intimation that they can specialize in generalism. Every specialist, if honest, will recall a student who was a generalist by nature and who would have preferred to have shopped around from department to department. Instead, he was literally shanghaied by the zeal of a proselyting specialist. Pre-requisites, the required, and other course-of-study falderal that might be cast in the Soviet mold, prevent his being rescued from that sad fate.

There are significant movements stirring within respected universities. Harvard and Yale have decided to emphasize general education as a preliminary to specialization. The department of Social Relations at Harvard is an example of independent courses being dovetailed into a single science. Some universities are providing survey courses in science for students who do not expect to become science specialists. There is also the effort to form a single integrated science. This means the bringing together into one family the interrelated botany, zoology, and geology. All three subjects are applied conjointly, thereby giving the student confidence in the validity of the movement in social work, education, industrial relations, and colonial administration. The National Science Foundation aims to promote research and education in basic sciences, a suggestion of organized research

UNIVERSITY OF MICHIGAN LIBRARIES

by teams, as distinguished from individual research. The Point Four Program of the United Nations (1950) means technical assistance in developing resources of undeveloped countries that they may enjoy higher levels of living. If one were to scan the assets of boys and girls brought in by Science Talent Scouts he would discover that each individual has talent in the arts and physical education field as well as in science. At the Mid-century Convocation held at the Massachusetts Institute of Technology it was brought out that material, spiritual, and intellectual problems cannot be compartmented. It seems evident that scientists as well as students want a philosophy of the science of life (Biology) that goes beyond astrology and horoscopes. There must be a twenty-four hour science, the science of the community as well as the science of the laboratory. Ordering one's life according to science does not seem to be an unreasonable request.

Another guide post to the predicament of the times are the titles of papers. The idolatry of "pure" science was debunked by Standen's *Science is a Sacred Cow*. Then there was the furor created by the senator when he discovered that the taxpayers were sponsoring bulletins on the *Sex of Watermelons*. A collector of titles would not bypass *Why do hens stop laying when prices are highest* or the *Sex Life of Mastodons before the Ice Age*. *The Psychological Warfare against Man-caused Forest Fires* would surely have precedence over *Morals to be Found from the study of Cockroaches in a Maze*. A chemist or florist might conceive that a thesis on the *Inhibitory Influences in Growing Poinsettia* is legitimate whereas the *Mating Habits of Colon Bacilli* or the *Micro-analysis of the Eyeballs of Fleas* might cause suspicion. Our democratic way symbolizes the freedom of the individual, everyday American citizen to be informed and enlightened, and not silenced by "dark" meaningless vocabularies. Also, the day is past when the generalist, or the specialist, will listen with feigned interest to a legitimate seminar outside of his ken, such as on Platyhelminthes, even though there be an effort to gratify him with a cup of tea. Perhaps he should listen to a panel on Soviet psychology, if you get the difference.

Some Questions for the Dean of Science

"Science is built up with facts, as a house with stones. But a collection of facts is no more a science than a heap of stones is a house." Henri Poincaré, Mathematical Physicist.

How many apostles of specialization are there in your organization? This species of scientist has little to do with education, citizens, or general reality. An endocrinologist may be a hermit amongst zoolo-

gists. He may have 1–3 satellites. Typically he is an isolationist who studies inert, pickled, or desiccated specimens. He resents being disturbed by students. He may have office hours on Saturday mornings.

What research papers are published by each specialist? Is the number of research papers the measure of success? What are the ear marks of a successful paper? Do the papers consist of a specialized vocabulary or is it in simple English? Does the problem have application to daily life? Does it have the attitude that no time should be wasted with the "dumb" public? Are there anecdotes?

How many of these specialists take sabbaticals for professional improvements? Pilots are forbidden to exceed maximum hours of flying. Pilots of science must also have a change to prevent necrosis. The "ivory tower" specialist can hardly ever be pried loose for improvement. In his own mind he doesn't need it. What do the specialists do in vacation time? A faithful old horse who had served well on a tread mill was rewarded by being given a vacation. When his benefactor went out to the passture to see how "old Bill" was getting along he found him going around and around a tree just as he had done at the mill.

What discriminatory practices can be detected? Does one brand of biologist have antipathy to another brand of biologist, such as botanists for zoologists? Or botanists have an aversion for one another? Does one "sect" deprive their own students the privilege of taking courses in geology, entomology, forestry, or wild life?

Is there a course in the unity of science? How does it differ from "fragmentized" science? Is it an illusion in any other way? Is it sort of a keeping up with the Jones affair when the Jones have gone on to something quite different? What is the evidence of a relation between scientific knowledge and daily living habits? Is it a sort of peace treaty?

What per cent of graduates trained in the specialized sciences stray into the generalized fields? Which of the following would you classify as general fields: natural science, biological science, agriculture, social science, medical science, health professions, engineering, teaching, conservation, government positions in administration, hotel administration, colonialism, human affairs? Do students go into general fields because of opportunities, because of the maturing of the specialized fields, or because of the contributions of generalists?

What per cent of your specialized scientists have a woeful lack of science comprehension? As far as they are concerned the "Golden age of science" is mere piffle outside of the laboratory. Popularizers of science are mere "scum" with whom no self-respecting scientist would be associated. Teen-age addiction to marijuana or heroin, to driver

education, and to youth organizations are molehills amongst mountains. Suckers for communism is a passing rash. How many of this group of specialists are on such faculty committees as course of study, educational policies, public relations, or honors?

How many of your specialists do not possess enough plastic quality to make for educability? Would he have rigor mortis if called upon to teach in a war emergency program? What evidence is there of his doing sociological service? Should he be classified as democratic or totalitarian? Is he utterly dependent upon society for financial or other support?

What is the demand for graduates with skills in two or more sciences? How many leaders are sought with training in journalism and science; physics and biology; engineering and bacteriology; geology and forests; education and recreation; hydrology and climatology; etc.?

How Does One Identify A Generalist

It is conceivable that an individual might be a specialized scientist in his professional hours and a human ecologist in his free time. There has been wide-spread opinion on the subject. Alexander Graham Bell claimed that a good scientist could explain his work to any intelligent layman and that it must be interesting enough to read. The *Science Newsletter* is an effort in that direction. Then there is the idea of the amateur scientist. Franklin, the printer; Mendel, the monk; Fabre, the writer; Asa Gray, the botanist; and Agassiz, the zoologist were more than their specialty. The last three were teachers. Goethe and Pavlov were Nobel Prize winners. Julian Huxley said that "science is not the disembodied sort of activity that some people would make out, engaged in the abstract task of pursuing universal truth, but a social function intimately linked up with human history and human destiny." H. G. Wells said that "Human history becomes more and more a race between education and catastrophe." Anyone who has followed the "Science Clubs of America," under the sponsorship of Science Service, has witnessed something significant. The outstanding youth are generalists, or idealists, interested in music, art, literature, and physical education. Poetry is not uncommon with them nor is it absent in the *Scientific Monthly*. Plato, in his *Republic* says that the poet "is very far removed from the truth." However, Wordsworth said that "Poetry is the image of man and of nature." That "A poet is a painter in words and a painter is a poet in visible forms" was the idea of Lionello Venturi, the modern Art Critic. Perhaps poetry to the scientist is what he makes it. As the woman passerby spoke to the landscape

painter Turner: "I have never seen a sunset like that." Turner replied: "Don't you wish you could?"

The writer has selected four generalists to illustrate his thesis. The assignment has not been easy. There are scores of examples that are worthy. No two scientists could possibly select the same names. The names chosen were arrived at by the following guide.

They must be *outstanding generalists*, who have toiled in the vineyard of science as successful naturalists. They are respected and might even be envied by science specialists.

They were *alert to the segments of science*, or at least had "vest pocket" respect for the compartments of science. They were skilled in earth science, botany, zoology, human ecology, and the outdoors. Above all they are *humanists*. They are not aloof to human behavior and regard each aspect as dignified and interesting.

They are *interpreters of nature*. They must have given the public an understanding and respect for science. They are crusaders for a cause. They have even built a respect and interest amongst taxpayers. The Zoo Parade; Science on the March; Animal Fair; David Dietz the Science Editor of Scripps Howard Newspapers; The National Geographic; and Nature Magazine are examples. Within my lifetime there has been a steady accumulation of bulletins, books, and periodicals that explain science in simple, brief, clear language.

They must be *recognized educators* as well as scientists.

They must have been *personally known* to the writer. Although all but one representative has "passed on" this makes it possible that the reader may have also known one or more of these "Cosmopolitans" in the orbit of science. Unlike Mark Twain's Connecticut Yankee who went to sleep in the 19th Century and woke up in King Arthur's time—this paper will refer to Americans who lived abundantly in our century. They set up a code of living, not only for the Rip Van Winkles of science who may have retreated to their caves, but more hopefully a justifiable attempt to liberate the *gifted idealist* bent on generalism rather than specialized enslavement.

Anna Botsford Comstock, Teacher

The "Dean of American Nature-study" was farm-born of gracious outdoor-minded, Quaker ancestry. As a student she traveled the fields and canoed Cayuga Lake with her science-specialist teacher, John Henry Comstock. Graduating from Cornell (1885), seven years after their marriage, it was not just happenstance that their home overlooked Fall Creek Gorge, or that it was the campus center of social life for the outdoor minded. Mrs. Comstock studied wood engraving so that she could help illustrate her husband's "Manual for the Study

of Insects." Her "Handbook of Nature-study," which John Henry said "Would never pay the printing costs" had, by 1947, attained its 24th edition and paid for the manual besides. We quote from the publisher's foreword in the last edition after being scrutinized by twenty-eight specialists: "Mrs. Comstock's work proved to be as accurate and timely in 1939 as in 1911, a striking tribute to the scientific genius of the author . . . the language of the earlier text has been preserved, for no improvement could be made on the charming style . . . the truth is that nature-study is more than a science . . . it is an experience of life." There is abundant evidence that Mrs. Comstock could write about specialized science, as "How to Keep Bees" (1905) and at the same time could pay aesthetic tribute to "Trees at Leisure" (1916).

If anyone believes that this world is an example that Nature teaches survival by physical fitness, hypocricy, deceit, or parasitism he should read Mrs. Comstock's "The Hermit of Dyer's Pond" (Nature-study Review, April 1923). It was an ideal June day on Cape Cod. "The sand hills displayed their wide spread rugs of bearberry and poverty grass as proudly as if they had been of ferns or clover." She saw his hen coops "made after the fashion of an architect who goes not to alien hands for his materials," his wild geese, his mallards "with their eleven ducklings swimming free in the lake;" where he fed the quail "and then we understood why we had heard so many confidential calls 'bob white,' 'bob white'; his ring-necked 'pheasant'; then I said to him "I understand why you are not lonely."

Her approval of such a homely style of inoculating nature-enthusiasm was stated in an editorial. "It is true that the teacher of nature-study in a camp has the most favorable conditions as far as environment is concerned . . . and yet many a nature counselor has failed utterly." Of the second Nature Lore School (1921) she wrote in the concluding sentence of an editorial that "It was as a whole a most interesting week helpful and inspiring alike to teachers and pupils" (Nature-study Review, April 1922).

The "Camp and Field Notebook" (Comstock and Vinal), a loose leaf system designed for the Nature Lore School, first organized under the sponsorship of the National Association of the Directors of Girls Camps (1920), was perhaps the first recognition that "the child shall have a book of his very own" (Nature-study Review, April, 1923, page 181). The participation in the nature lore movement of such other generalists as Edward Howe Forbush, Schuyler Matthews, and Dallas Lore Sharp were tributes to the cause.

If other testimony were needed as to Mrs. Comstock's "greatness" we might add that she was the first woman to be appointed assistant professor at Cornell University (1918) and professor (1920). The

National League of Women Voters (1923) chose her as one of "Twelve who have contributed most in their respective fields to the betterment of the world." In 1930 Hobart College awarded Mrs. Comstock the honorary degree of Doctor of Humane Letters.

Probably Cornell University, more than any other institution, has more consistently and for a longer period of time championed the training of naturalists. This is due to such generalists as Liberty Hyde Bailey, James G. Needham, and E. Laurence Palmer. Although the writer has worked jointly with Dr. Palmer, he felt that it was fitting to pay tribute to Anna Botsford Comstock as the "Dean of American Nature-study." His appreciation and indebtedness for nature and human welfare goes back to Anna Botsford Comstock.

Vilhjalmur Stefansson, Explorer

As Vilhjalmur Stefansson left Harvard in 1906, we were classmates. "Stef" originated at Lake Winnipeg, Canada (1879). His parents were born on the north coast of Iceland. At the age of one he took his parents to North Dakota. Here he attended school winters, and was a cowboy summers. His first experience on a moving railway train was in 1896 when he set out for prep school at Grand Forks. He was successively student, teacher, and high school principal. At 22 he ran for the office of State Superintendent of Schools, although the state constitution said that one must be 25 years old. Before 23 he was a stump speaker in the Democratic campaign for free trade and anti-expansion. In about 1902 he left the state university, by request of the faculty, although the president was on his side. He tried to lose his identity so that he could enter another university as a freshman. He discovered that one could get credits in German if he learned it in school but not if he knew German because his parents were German. As a delegate to the World's Congress of Liberal Religions in Boston he met the president, Samuel Eliot. Harvard was big enough to admit him. With some misgivings he entered Divinity School. "Stef" was a "consumer" at Randall Hall where I was a "dispenser." This "chance meeting" was the beginning of an acquaintance.

"Stef's" first scientific expedition was to Iceland (1904). The report "was more linguistic and historical than anthropological" Eskimos became a fascination. He soon learned that they might be ignorant of book learning but that they retained integrity and self-restraint. Being a "rebel against tradition" he also learned that thawing a frozen ear by applying a snowball was plain superstition. In some places the missionaries had made the Eskimos Christians. Although the Eskimos had practiced the Golden Rule before the Pyramids were built, and equalled the best of our "Christian Virtues,"

UNIVERSITY OF MICHIGAN LIBRARIES

they found it easy to adopt our taboos. In the past they had the harvest when the leviathans arrived. Now they refrained from work on Sunday and suggested that the missionaries ask God to have whales come on week days only. Stef also observed that while the missionaries were gathering money to send city invalids to fresh air camps they were herding open air people in houses where the reward was stomach-aches, and scurvy. To anyone freed from the so-called New England conscience this was delightful reading.

Stef differed from the "would-do-gooders" in that he went to learn instead of to teach. To do this he traveled on shank's mare, swam, floated on rafts, and was once marooned on an ice floe, 4×5 miles surrounded by miles of open water. He was as great a hunter as Sergeant York. He learned to eat as the Eskimos, to drink 2 pints of blood soup at a sitting, and to munch on snow-shoe lashings if necessary. His approach was always impersonal, that is, after the style of a true scientist. Once when introduced to talk on "Courage" he changed the word to "Adaptability." When asked if he got to the North Pole his answer always was "No I'm a scientist, not a tourist." Perhaps he considered it a challenge to his statements about the "Friendly Arctic." He accepted the invitation of the Russell Sage Institute of Pathology (1928) when he ate meat for a year without ill effect. His first scientific paper was on the origin of grammatical gender in a philological journal. It is remarkable that, through the door to the ministry and philology, he was still able to arrive in the field of greatest devotion, that of science.

One of Stefansson's great contributions to science was the discovery that the blond Eskimos, with blue eyes, beards, and curly hair, descended from Norse explorers. Eric the Red, the father of Leifr, early in the 10th Century, visited Greenland, Iceland, and later America. In reading "My Life with the Eskimo" (1919) one realizes that Stefansson "from childhood had been familiar with the literature of the North." His notes on the spot indicated that he knew that he was standing face to face with an important scientific discovery: "I now understand why the Cape Bexley people (The first Eskimo discovered by us) take me for an Eskimo."

In the Forty-fifth Anniversary Report of the Class of 1906, Stef writes that he has been "involved mainly using books written by others for making books signed by me—that stealing from two or more other writers which is called research." He could afford to say this as the scientific collections of his three expeditions are in various Canadian and American museums. It took 17 volumes to record them. *The Encyclopedia Arctica*, a twenty volume set for the office of Naval Research U.S. Navy, at that time consisted of one volume in geology, two in botany, and two in zoology. His popular books such

as *My Life with the Eskimo* and the *Friendly Arctic* (1921) have been translated into Czechoslovak, French and German. One book is in Russian. Few specialized scientists have been more prolific.

Amidst it all Stef has found time to run "Operation Snowshoe" and other activities for the Scouts. He is recipient of the Silver Buffalo, the highest regular reward of Boy Scouts. He has received honorary club memberships and medals. The Universities of Manitoba and Pittsburgh have awarded him doctorates.

Stefansson never lost his "wholesale" interest in the natural sciences. His contributions of generalized knowledge about the great northland from the fields of geography, meteorology, archaeology, and ethnology are significant. Today's stratoliners flying direct routes, may be dependent on knowledge gained by rugged individuals who dared to follow their interests in generalized science, not only that met in the Arctic but in the mountains, coral reefs, volcanic islands, and deserts. During World War II the writer asked to organize a course in "survival" for sophomores. The course of study committee, even when enlisted men were perishing in the jungles and mountains, reported back that such a course was not basic science. Of course it did not occur to "the elite" to ask college students. Even in these days of witch hunting, I do not question the motives of missionaries or of scientists. I do challenge their judgment. That might is not necessarily right has been shown many times in the evolution of civilization. The *Autobiography of Vilhjalmur Stefansson*, which is due to appear in 1953,will be one that portrays the essential conditions for the education of youth in the spirit of science. Time and time again he might have been exiled from science or shuttled into a cubicle of science. I trust that one chapter will be entitled "Let's Develop General Scientists among Youth who are Devoted to Human Ecology."

(To be continued)

BIG EARTHQUAKE DAY SHAKES EARTH

Mother Earth stirred and grumbled quite a bit Thursday, Feb. 26.

"We haven't had a day like this for months," seismologists at the U. S. Coast and Geodetic Survey said as they watched their instruments dance to the tune of four fairly large quakes in a period of 18 hours.

Three of them were in the Aleutian chain of islands extending toward Siberia from Alaska, One was way out at the western end of the chain, in the Near Island, close to—or rather, near—Attu of World War II fame.

The fourth was in the Santa Cruz Islands, 3,000 miles southwest of Hawaii. This precipitated a slight tidal wave scare, but the wave did not develop.

ROME'S CONTRIBUTIONS TO NATURAL SCIENCE

A. Postl
Oregon College of Education, Monmouth, Ore.

Nearly everyone is aware of the great contributions to the natural sciences made by the Greeks. The great age of Greece was followed by the rising power of Rome. It is this great Roman Period in world history with which this discussion primarily concerns itself.

Right at the outset one finds a tremendous difference between the contributions to the natural sciences made by these two great cultures. A volume like the *Source Book in Greek Science* by Cohen and Drabkin[1] has as yet, at any rate, no counterpart for Rome.

Harvey-Gibson[4] in his *Two Thousand Years of Science* makes no mention of any Roman Period in science.

F. Sherwood Taylor[8] in *A Short History of Science and Scientific Thought* also shows no Roman Period in his Time Chart of the Main Periods of Science. Sarton in his book, *The Life of Science*, has this to say about Roman Science:

". . . Roman science even at its best was always but a pale imitation of the Greek."

Sarton[6] gives also the following reasons for the difference in their contributions to the natural sciences.

"The Romans were so afraid of disinterested research, the excess of which had been one of the causes of Greek corruption. . . ."

"We may say that the Greek spirit, that disinterested love of truth which is the very spring of knowledge, was finally smothered by the combination of Roman utilitarianism and Christian sentimentality."

While the difference of love of knowledge by the Greeks on one hand and the utilitarian attitude of the Romans on the other hand may be as good an explanation as could likely be advanced by anyone it appears that one might question the Christian sentimentality as being a factor in those early days of Christianity though autocratic rule by the Curch Fathers of later years was undoubtedly a strong contributing factor to the decline of science during the Dark Ages, and even then it was hardly the sentimentality of it. Dampier[2] in *A History of Science* has this to say in his section on the Roman Age:

"They used the stream of knowledge without replenishing its source—the fount of learning for its own sake—and in a few generations the source, and with it the stream ran dry."

He also, interestingly, points out that there was actual opposition to the coming supremacy of Greek thought.

Charles Singer[7] in his science section of the book *The Legacy of Rome* also mentions this opposition on the part of the Romans to the "newfangled material from Greece," and he says further that

pure science was exotic to the Romans while applied science held quite an attraction for them. He also mentions that the "general scientific principles of the Greeks were seldom understood even by the educated Greeks." Should one see therein the cause for the aforementioned opposition or might it possibly just have been a sort of jealousy? In another section Singer makes the blunt statement that:

"Rome produced no great creative scientist."

To the credit of Roman Science it should be stated that in their attitude to and interest in nature they made great contributions. Their other forte of applied science is exemplified in their many fine contributions to sanitation such as water supply, sewage disposal, and hospitals. In general the work of the Romans consisted primarily in transcribing and organizing the works of the Greeks though few actual translations to the Latin were made.

The remainder of this brief discussion on this subject will be a chronological listing of some of the more outstanding men of Roman Science and their contributions. Taylor[8] in another Time Chart of Greek and Latin Science shows that the height of Roman Power falls between 100 B.C. and 100 A.D. The decline of the Roman Empire begins in the third century and the Sack of Rome takes place during the fifth century. Nearly all of the more important contributions of Roman Science fall during the height of the Roman Empire. Singer[7] notes that the Latin literature contains no scientific element prior to about 214 B.C.

In 168 B.C. Greek hostages brought to Rome the library of a Macedonian King which may be one of the reasons why the Roman contributions follow this period.

MARCUS PORCIUS CATO (234–149 B.C.) wrote a Latin text on agriculture.

POSIDONIUS, a contemporary of Cato, was an astrologer and astronomer and in the latter field contributed to the explanation of the cause of the tides. It is in the writings of these two men that opposition to the rise and influence of Greek thought is detected.

MARCUS TERENTIUS VARRO (116–27 B.C.) went to Athens where he came under the influence of Greek philosophy, particularly that of Plato. In his encyclopedic work, ***Rerum Rusticarum***, Libri III he includes in his nine liberal arts the following scientific areas: geometry, arithmetic, astronomy, medicine and architecture. He studied also the growth of plants and connected the contagion of diseases to the existence of microorganisms.

MARCUS TULLIUS CICERO (106–43 B.C.) wrote a cosmological work entitled *de Natura Deorum* in which he propounds a teleological theory of the human body.

UNIVERSITY OF MICHIGAN LIBRARIES

TITUS LUCRETIUS CARUS (98–55 B.C.) in his work *de Rerum Natura* defends atomism but Dampier[2] feels that the work of these last two Romans is merely a popularization of Greek Philosphy.

GAIUS JULIUS CAESAR (100–44 B.C.) is well known for his calendar revisons.

LUCRETIUS (96–55 B.C.) though primarily a poet expressed also atomistic views in his writing *"de Rerum Natura."* The following two statements of his can well be looked upon as an early form of the Law of Conservation of Matter.

"Nothing is ever begotten of nothing by divine will. Things cannot then be ever turned to naught."

His observations on magnetism drew later the attention of William Gilbert. In the realm of biology he established an evolutionary ladder of life, *Scala Naturae,* which, however, had its origin in spontaneous generation.

VIRGIL (70–19 B.C.) though again primarily famous as a poet wrote also in his poem Georgics on the art of agriculture.

POLLIO VITRUVIUS (31 B.C.–14 A.D.) was an architect and he wrote a book in which he recognizes the importance of acoustics and sound as a vibration of air.

LUCIUS ANNAEUS SENECA (3 B.C.–65 A.D.) is according to Singer[7] scientifically superior to Pliny in that he at least verified some of the statements. He wrote *Quaestiones Naturales* in which he discusses astronomy, meteorology, physical geography, and earthquakes which Singer[7] in spite of his earlier praise calls borrowed material which is imperfect and in addition ill arranged.

CELSUS wrote in 30 A.D. *De re Medica,* a compendium of eight books in medicine and surgery, the material for which was again largely of Greek origin.

Pliny (23–79 A.D.) is undoubtedly one of the greatest men of this period to be considered though even he again made few, if any, original contributions. It is noteworthy, however, to mention that he himself did not make any claims to the contrary. To quote his own words he says in his preface to his *Natural History:*[5]

"You will deem it a proof of this pride of mine that I have prefaced these volumes with the names of my authorities. I have done so because it is, in my opinion, a pleasant thing and one that shows an honorable modesty, to own up to those who were the means of one's achievements, not to do as most of the authors to whom I have referred did."

His *Natural History* comprises 37 books which cover the following topics:

NATURALIS HISTORIA

Book I. Table of Contents and Authorities

II. Astronomy and Meterology
III–VI. Geography
VII–XI. Animal Life
XII–XVII. Trees
XVIII–XXVII. Crops, Herbs and Drugs from Plants
XXVIII–XXXII. Drugs from Animals
XXXIII–XXXIV. Metals
XXXV. Painting and Sculpture
XXXVI–XXXVII. Stones and Gems.

Two rather interesting observations may be made from even a casual perusal of his works. One is his position on astrology where he apparently contradicts himself. Though he discounts astrology early in his work he later considers comets to be portents and even more surprisingly he considers man related to the stars and man's soul as a part of heaven. The other interesting observation is his position on God. In this respect he is far ahead of his time when he says:

"For this reason I deem it a mark of human weakness to seek to discover the shape and form of God."

His own concept of God approaches an eternal, immeasurable being that is inherent in the power of nature as manifested in the "world." The very fact that he speaks in monotheistic terms is again a mark of advancement of his thinking while living in a polytheistic society.

Pliny's scientific spirit is exemplified even in the manner in which he met his death. He died during the famous eruption of Mt. Vesuvius which instead of causing him to flee aroused his curiosity to investigate.

JULIUS FRONTINUS SEXTUS (40–103 A.D.) was CURATUR AQUARUM and in this connection made a number of contributions to the field of hydrodynamics.

PLUTARCH (ca. 50–125 A.D.) wrote on the constitution of the moon. He also wrote comparative biographies of Greek and Roman writers and was himself a Greek.

GALEN (ca. 130–200 A.D.) was born in Pergamos, Asia Minor, and he too is actually Greek in origin and by training but is usually considered part of the Roman Period because he did most of his work in Rome. He was physician to the Emperor Marcus Aurelius. Greek medicine had already been introduced to Rome by Asclepiades more than two centuries before Galen. Galen's own work wielded, however, a great influence in medicine for a number of centuries afterwards. His medical writings include the fields of anatomy and physiology. His experimental work and observations in these two fields though not always correct were an outstanding contribution of his day. Though he was a great admirer of Hippocrates, in fact to the extent

UNIVERSITY OF MICHIGAN LIBRARIES

of referring to him as "Divine," he broke, nevertheless, with some of the Greek medical tradition in that he considered the "Nature" or unity of the whole body as important while the Greeks, the Empirics, were often more concerned with the cure of the symptoms. In some of his views of medical specialization, ethics, and qualifications of a physician he could well be emulated by his profession of today.

His most famous work is *On the Natural Faculties* which consists of three books totalling fifteen chapters and is primarily a treatise on medicine.

BOETHIUS (480–524 A.D.) who wrote *Geometrica and Arithmetica* is as can be seen from his dates one of the last Romans of that great period of Roman History to have made any notable contribution to the natural sciences.

Bibliography

1. Cohen, M. C. and I. E. Drabkin, *A Source Book in Greek Science*, McGraw-Hill Book Company, Inc., 1948.
2. Dampier, William Cecil, *A History of Science*, The Macmillan Company, New York, 1949.
3. Galen, *On the Natural Faculties*, Arthur John Brock, Translator, William Heinemann, London, 1916.
4. Harvey-Gibson, R. J., *Two Thousand Years of Science*, A. & C. Black, Ltd., London, 1931.
5. Pliny, *Natural History I*, H. Rackham, Harvard University Press, Cambridge, 1944.
6. Sarton, George, *The Life of Science*, Henri Schuman, New York, 1948.
7. Singer, Charles, *The Legacy of Rome*, Edited by Cyril Bailey, At the Clarendon Press, Oxford, 1923.
8. Taylor, F. Sherwood, *A Short History of Science and Scientific Thought*, W. W. Norton and Company, Inc., New York, 1949.

ANNOUNCEMENT

Indiana University invites you to attend its Sixth Annual Workshop for Teachers of Mathematics. The dates of this workshop are June 22 through July 3. During this workshop the membership will have the opportunity of hearing lectures on the needs for mathematics from the fields of business, industry and science; of participating in groups studying problems pertaining to the teaching of mathematics in grades 7 through 14. There will also be provided time and instruction in the field of laboratory materials for mathematics. Two and one-half hours of university credit will be given to those who desire it.

The director of the workshop will be Mr. Walter Gingery, Visiting Instructor in Education, and Mathematics Teacher in the University School, Bloomington, Indiana.

If you desire further information please write to

Philip Peak, Assistant Director
Workshop for Teachers of Mathematics
School of Education, Indiana University
Bloomington, Indiana

SOME TECHNIQUES OF A CONSERVATION TOUR

RAYMOND KIENHOLZ
Professor of Forestry, University of Connecticut, Storrs, Conn.

During the summer of 1951 the University of Connecticut conducted a country-wide tour designed to study the natural resources of the United States. This trip covered 12,000 miles through 26 states and took 2 months to complete, June 27 to August 25. The route covered the northern part of the southern tier of states to Southern California and up the West Coast to Washington and back by the northern tier of states.*

There were 30 of us travelling by bus, and two who operated the mobile "mess truck" which furnished the group with meals. The members of the tour came from Illinois (1), Ohio (3), Pennsylvania (3), New York (2), Massachusetts (2), Maine (1), West Virginia (1), Germany (2), and Connecticut (17). Of the 32, 20 were women, 12 were men. In ages they ranged from 19 to 62. As to occupations they ranked as follows: teachers; (college) 3, (secondary schools), 7, (elementary schools) 12, students 6, greenskeeper 1, machine research worker 1, housewife 1, extension worker 1. All of them were interested in conservation as a teacher or because of personal preference, even though engaged in some other work. Many had attended one or more Conservation Workshops as follows: Connecticut (7), Rhode Island (4), Ohio (3), Pennsylvania (2), Audubon: Conn. (2), Audubon: Maine (4). As to their educational training, they ranked as follows: PhD's (2), Master's (9), Bachelor's (15), no degree (6). The teachers had the following number of years' experience: 20 or more years (10), 10 to 20 years (7), less than 10 years (6), none (9). This varied experience and training was somewhat equalized by their more uniform training and experience in conservation.

Many of them had taken long overland motor trips or had some camping experience. Others had experience with youth groups, summer camps and adult education.

With this background I shall discuss some of the techniques used before, during and after the trip, and some of the responses of students to these methods. Criticism and evaluation of these techniques is based on my own observations of student reactions, conversations with the students, checking over the notebooks and on the answers to several questionnaires sent to the students. The first questionnaire was based on one prepared by Miss Nancy Wilcox who used it to secure data on educational tours in which secondary and ele-

* The tour is more fully described in *Conservation Across the United States* by Raymond Kienholz, SCHOOL SCIENCE AND MATHEMATICS, March 1953. Vol. 53: pp. 178–186.

mentary teachers participated. Her doctoral thesis from Cornell is published as "Educational Travel Courses for Teachers," F. A. Owen Publishing Co., Dansville, N. Y., 1953.

Out of 31 students on the tour answers to the questionnaire were received from 30. Many made suggestions regarding practices not listed in the questionnaire which they thought would be valuable. These suggestions were sent to the students with the request that they express their opinion regarding them. A smaller number answered this second questionnaire, but from it some valuable ideas were obtained. They will be discussed toward the end of this article.

The original questionnaire listed 22 selected practices of the "pre-travel session" and 54 selected practices "while en route." Each of these were to be rated according to their value to the individual in improving the travel experience. This rating varied from +3, meaning "extremely helpful—makes or would make a strong contribution to the travel experience" through 0, meaning "no effect at all either good or bad" to −3, meaning "extremely harmful—will interfere with the travel experience a good deal." N meant "no opinion one way or the other."

The ratings were to be listed in two separate groups based on whether the student had had personal contact with the practice or not. The answers received from my tour members varied, some saying they had had personal contact with the particular practice under discussion, others saying they had not had such contact. This was due in most cases to varying interpretation of the practice as listed in the questionnaire, especially when it did not quite cover the practice as we had carried it out on the tour.

In general the tour members rated those practices with which they had personal contact *higher* than those with which they were unacquainted. This was not always the case however. If there was some very desirable practice which we did not use the students ranked it high.

We did not hold a pre-travel session in the sense of a several days or a week long gathering at the University before starting out. In some ways, such a session would have been desirable, but time was a limiting factor. We needed every bit of our 60 day period to see things in the field. A longer session would have been undesirable as many felt that even 60 days was rather long. However, extensive correspondence was carried on with each student and much pre-tour material was sent to them. A short training session was held the day before we started on the actual trip. This consisted of erecting tents, rolling and unrolling bed rolls, checking over baggage and personal equipment, as well as getting acquainted with each other. In the evening a social gathering furthered our acquaintance and also

gave me a chance to outline briefly the purposes and practices of the trip.

In order to summarize the ratings for any given practice, they were added algebraically and divided by the number of ratings for that practice. Thus a rating of 3.00 indicated that everyone answering considered the practice a highly desirable one. A rating of 2 or above indicated a favorable reaction. A minus figure indicated an undesirable reaction. A minus rating was seldom obtained as most of the practices were considered to have little or no effect (0) or slightly harmful effects (−1 or −2) but seldom extremely harmful (−3). Whatever −3 ratings there were were counter-balanced by −2 or −1 or even plus ratings; hence the average would seldom be a minus figure.

Only some of the more desirable and some of the more undesirable practices will be discussed with their average ratings given.

"Pre-Travel" Practices

Of the pre-travel practices, the most valuable were the letters and suggestions sent out before the tour. (The students ranked these as 2.93 and 2.79.) These consisted of suggestions for securing camping equipment, lists of things necessary for the trip, the itinerary of the trip and general information of each state through which the tour passed. Also rated very high (2.54) was a list of those going on the trip with addresses and a short statement of training and experience. Suggestions for pre-travel reading also ranked high (2.41), as did marking the route covered on the students' maps (2.32). Making folders of local areas available (2.21) and showing slides of the area to be covered (2.18) were ranked high, although these were done in our case to only a limited degree.

Some desirable practices which might have been of value had time permitted were training in skill of accurate observation (2.11), lists of "Look fors" given to members (2.07), discussion as to the duties of the members (2.07) and conversation between staff and members (2.04). However, our group was for the most part responsible, mature and experienced with some training in conservation and in educational methods; hence did not need such practices as much as a younger, untrained group would have.

The least desirable practices of the pre-travel period as rated by the members may reflect a revolt against too much educational method since the lowest rank and the only minus rank was reserved for "Diagnostic tests are given" (−.15). It was also considered unnecessary to have "A short trial-run trip to show tour procedures" (.96), although such a trip, or at least some practice, might have been desirable, especially for the mess truck. The individuality of the

members was reflected in their lack of enthusiasm for having a person recording the day's activities and then giving this record to each traveller for his file (1.21). The same was probably the cause of a 1.23 rating for "files or work books are provided for travellers" and the 1.28 for "formal lectures are given by staff members." Other similar rankings may have been due to a feeling against too much formalization of the tour practices.

"En Route" Practices

Those practices while travelling which were rated most valuable by the students were in most cases those which were in effect on our tour. They realized clearly the fellowship and fun generated as a result of "travellers usually eat meals together" (2.93). This was one of the most valuable and pleasant experiences of the tour and was certainly an education in group living even if not in conservation of natural resources.

Likewise, the experience of sharing the intimate knowledge and enthusiasm of the local experts was recognized as of great value by a rank of 2.93 for "lectures are given by the residents of the areas through which travelling." And to make this experience possible they voted 2.90 for a "loudspeaker system in each riding conveyance." Along similar lines the members visited with other campers, with merchants, gas station operators, and as many of the local people as time and opportunity permitted. These conversations fitted to some extent the practice of "informal interviews are held with people of the areas visited" (2.86). This is a splendid teaching device which should have been used more than it was, but it is very time consuming.

I had expected to have a doctor with us on the tour, but last minute family demands prevented him from going. The tour members expressed their feeling by giving a high rating (2.90) to "A nurse is a member of the staff." They also favored a practice which I had insisted upon, "Each tour member must have passed a physical examination" (2.79).

Several practices that affected their group living from day to day were highly regarded by the students. "Group singing was a frequent activity" (2.86) was carried out in the bus daily and also frequently around the campfire. They changed places in the bus every day (2.79) according to a posted schedule, thus allowing everyone to get better acquainted and to break up any tendency to form cliques. The friendships formed were so satisfying that a demand arose before the trip was ended to have a reunion in October following the tour (2.79) at which thousands of colored slides and snapshots were viewed and duplicates arranged for. These many slides and snapshots also accounted for the lack of interest in having a photographer along (1.21).

In fact an informal organization was affected while travelling homeward which has gotten the group together for 4 reunions in all since the trip. These reunions have taken the place, in part, of a "post-travel period for summary and evaluation" (2.50).

As to business arrangements the practice of "travellers pay one fee which covers all expenses" (2.79) met with strong approval. Of course, purchases of souvenirs, refreshments and similar things was strictly up to the individual, as was also an occasional meal purchased out, usually on Sunday, to give the cook a rest.

"Observation periods followed by group discussion are held" (2.73) was highly rated by the students as was also "The holding of sessions to discuss and interpret what was experienced and to plan for the future" (2.64). These closely related topics were not taken up formally, but there was always a chance for discussion while visiting a project and informal questions put to me or to others of the group to clear up moot points. The members being mature and experienced did not take to over-organization as evidenced by the low rating given "Each staff member provides time in his daily schedule for counseling individual travellers" (1.15).

Other educational methods were appreciated as "travellers keep diaries" was rated 2.73. All did keep a record which was drawn on in preparing their note-books. They also appreciated the fact that both undergraduate and graduate credit was given (2.66). A further device of giving the day's schedule of activities was appreciated (2.64), although this usually took the form of a short talk over the loudspeaker indicating where we were going and what to look for supplemented by observations during the day by local experts riding along with us or by members of the group familiar with some phase of the work. Local experts often provided us with bulletins about their projects (2.59) which were saved and used in the final report. Some local slides and movies were shown which were excellent (2.50), and I'm sure more could have been done along this line, although this is largely up to the local experts.

Some suggestions for more leisure time (2.64) were made to me during and after the trip, but the tight schedule we had to maintain allowed such leisure only at odd times, and on some evenings and Sunday, which was usually a rest day (2.43). Some requested more time to take photographs, but I found that if one person wanted to stop for a picture, everybody piled out and nearly a half hour was consumed. This could not be repeated too frequently and still keep on schedule. A looser schedule should probably have been worked out.

One of the desirable things about the trip was the informality and the lack of regimentation outside of meeting the schedule. The

UNIVERSITY OF MICHIGAN LIBRARIES

members felt free to make suggestions for the improvement of tours during and after the trip (2.48). Although I was the coordinator of all activities (2.31) which seemed to meet with general approval, there were older women on the tour who were helpful to the younger women (2.52), thus acting as staff members. In fact, the group governed themselves in large measure and worked out many problems among themselves. Social activities were often organized spontaneously by the members of the group and the system of K.P.s, 5 of whom served each day, although posted daily, was altered if someone could not serve for one reason or another.

Now to have a look at some of the practices rated as less desirable by the tour members. Again at the very bottom of the list, "Diagnostic and accomplishment tests are given periodically throughout the tour" (−1.22). Similarly a low rank was afforded "Travellers anonymously evaluate staff competence and the results are used to improve the tour experiences" (.20), and "traveller's evaluation of individual and group growth is periodically undertaken" (.43). It was felt that these two practices were risky for harmony, might not be constructive nor anonymous in every case and should be left to the staff at the end of the tour. They likewise did not favor travellers with special talent painting scenes, working in ceramics or writing impressions (.19), nor making recordings of discussions and playing them back (.89). Decided objection arose to the setting a limit "On the number of tours in which a traveller can participate" (−.82), some of them admitting they rated it thus for selfish reasons. Likewise they rated "applicants can be rejected because of age" as a low (−.04) probably because some of the older members of the group were among the best travellers and most likable tour members. As many said, "Other things are more important," health, spirit and temperament. "Management of the tour funds is carried on by members of the tour as a learning experience" was frowned upon (−.14) as confusing, as a burden, and of advantage only to one expecting to organize his own tour.

"Formal lectures" by the staff were not relished (.93), I hope only on the basis that "informal" were better! Informational reports made by tour members to the group was not rated very high (1.69) except in the case of one of our members with a Ph.D. degree and years of experience in travel and in teaching geology and geography, who passed on to the group much appreciated knowledge.

The reading aloud of appropriate literature (1.14), "Making available newspapers of the area visited" (1.17) gathering pictures and clippings for a group scrapbook (1.37), recording the group's activities by one person for the whole group (1.39) and similar devices were not rated very high. Some of these and other good teaching

devices were not highly regarded by the group since they were older, more mature and already somewhat trained along these lines.

Additional Suggestions

Some of the most highly individualistic and interesting suggestions were received when the first questionnaire was returned. These suggestions often reflected the personality and the strong opinion of the tour member sending them in. But they were not always highly regarded by the other members. Quite naturally some of these suggestions paralleled or directly refuted those made by someone else. Nonetheless, I sent them all out to the members of the tour in a second questionnaire. These suggestions are particularly valuable since they represented the travellers' own ideas of those things which they disliked, as well as those which they liked. Four different suggestions for reducing the size, weight and number of pieces of baggage and enforcing limitations on these items all received very high ratings. This was a natural reaction to a crowded bus and a realization that all of us could have gotten along without many items which we lugged along with us, thinking they were necessary. Some of the male members made the suggestion that this limitation should be enforced with particular regard to the women. They in turn promptly refuted the slur, even though favoring the general idea.

Camping out in the open close to the sources of information was ranked very high in two differently worded suggestions. They also favored local experts teaching as the bus travelled along.

The travellers strongly approved the idea that rest days should be days of leisure with no pressure brought to bear on the individual to conform to any particular pattern or program. This attitude was further shown by the group favoring the idea of planning some of their own worship services, although others expressed the thought that the "Woods were God's first temples"; hence were unexcelled places for worship. On our tour Sunday was usually a free day with attendance at Church provided for as much as was possible under the conditions of our travel. However, the feeling persisted that Church worship should be made possible followed by the necessary day's travel.

Song books for all travellers was rated very highly.

The suggestion that all tour members should understand fully before the trip what their responsibilities would be with regard to notebooks, kitchen help and other duties was rated high. In a pioneer trip such as ours, the amount of such help is difficult to determine in advance, but the kind of work expected should be made clear.

One of the controversial points on the tour was how frequently

UNIVERSITY OF WYOMING LIBRARIES

should we stop for photographs of some item of special interest? The interests of some were rather narrow and the interests of all the group were very varied. Theoretically, stops for photos should have been frequent, but usually this was impossible, and I had to decide whether the day's schedule would allow such stops in the light of the importance of the subject to be photographed.

Assigning space in the bus for baggage and collected specimens was always a source of difficulty, particularly since we changed our seats each day. Suggestions for removing all baggage from the bus each night were not well received, as such a practice would have been more time consuming packing up in the morning. Getting in and out of the bus is always a difficulty as some are fast and some are slow. A semi-military method suggested was not well received, but the suggestion that everyone should be impressed with the necessity for keeping the aisle clear and moving in and out rapidly was rated high.

A controversial item was the matter of note taking. Several suggestions for appointing one or more persons to take the notes for one day, check them for accuracy and then have them mimeographed for distribution was warmly defended and more warmly condemned. The difficulty of all members of a group hearing the speaker in the field is often great, but the interests of the individual note-takers are so varied that the opinion favored each person taking his own notes. Individual note taking is a good way of impressing the facts in one's mind. A suggestion that every other evening a short time be given to a review of the most important activities of the previous period was well received.

Allied to this were several suggestions that a period should be given over at the end of the trip to going over the material gathered and the notes taken to assure their completeness and accuracy. Others thought this would be an anti-climax and less valuable than spending that time in travel. The best way would probably be an occasional day or evening given over to a review of the projects covered during the previous week or two. One evening around the campfire at Ft. Peck Dam, Montana, the group went over every night's stop and every day's happenings by way of review and the accuracy of their memories was reassuring. The notebooks handed in bear this out.

The lowest rated item of all was a suggestion that the group be limited to twenty. The selfish view "If that were enforced, I could not have gone" was frequently stated. I believe twenty would be a better number in some ways, but in others, a larger number is more desirable, not the least of which is the lessened expense to each traveller.

Some felt a flexible schedule was desirable, others insisted on rigidly following a schedule and never varying from it even as to overnight stops. Both of these extreme positions are untenable. If local specialists are to join the group, the schedule must be adhered to. If no guests are to meet us, overnight stops could be altered somewhat, although this cannot be done in very many cases. In general, a fairly tight schedule is necessary.

A request for a detailed account of the distribution of the fees collected was rated very low, as was a plan for regulations as to time of getting up and going to bed so others could sleep. The best way to solve this last problem was to take one's sleeping bag far away from the rest of the crowd.

Mail stops (13 on the trip) were generally satisfactory, although some thought they should be more frequent, and also that there should be more frequent sending out of mail. Shopping stops were also a matter of some difference of opinion.

Food was very well prepared, tasty and abundant and no criticism was expressed except by the operators of the mess truck who thought that radio communication with the bus would be desirable.

Most of the suggestions made had to do with day to day living rather than educational methods as such. However, a satisfied student is a more receptive student; hence such matters are of importance. The suggestions should be of great help in planning future tours.

The "proof of the pudding" is the fact that all the travellers were very enthusiastic about the tour and felt it was one of the most interesting and worthwhile experiences they had ever had. They have repeatedly told me of the many uses they have made of the material and experiences gathered on the trip, as well as the friendships formed.

GALILEO'S DIALOGUE

On September 26, 1953, the University of California Press will publish Galileo Galilei's "Dialogue Concerning the Two Chief World Systems, The Ptolemaic and the Copernican" ($10.00). This English translation has been prepared and annotated by Stillman Drake, and Albert Einstein has contributed a Foreword to the work.

One of the greatest classics in the history of science the *Dialogue* has not been available in English for three hundred years, though it is the book which did most to demolish religious and academic barriers raised against free scientific inquiry.

The translation now in press is entirely new. It is designed to preserve the engaging and stimulating tone of the original. Readability has been preferred to abolute literalness, though care has been taken to render the text faithfully. It is believed that lay readers as well as scientists will be captivated once more by the bold and shrewd spirit of Galileo as men were three centuries ago.

ON THE SCIENTIFIC METHOD

CHARLES A. COMPTON
Mount Hermon School, Mount Hermon, Mass.

In a recent article in SCHOOL SCIENCE AND MATHEMATICS reference was made to the "method of procedure called the scientific method." This article is not alone, for almost every month of every year someone writes, as I am now, on the scientific method.

In all of the articles that I have seen on this topic, there has been an emphasis upon three major characteristics of the famous method. First, there is the certain pattern which, if followed, seems to constitute the scientific method. This pattern usually consists of several steps: observation, formulation of hypotheses, testing by experiment, and the final formulation of some sort of law or fact or theory. In one popular magazine not too long ago, this pattern was reduced to three steps. Second, the scientific method is always characterized as being impersonal and coldly calculating. Third, true scientific method is free from the misleading effects of intuition, emotion, revelation or guess-work. These three items are usually modified to some extent, but in most cases where the article is for popular consumption there is a definite attempt to leave the reader with the above picture. I wonder how men who have dedicated their lives to science would feel about it?

There is a very great desire, even in the United States, to find the simple explanation, the one word answer, for any situation that occurs. A sunk ship or a murdered prince was the cause for a war; a sneak attack sent another nation to war. Crime can be abolished if all criminals are deported; there will be no subversives if all outspoken men are silenced. The desire to find the simple answer may be the reason for the popular concepts about the methods of science. If so, then it is time for thinking men and women to speak out and proclaim that science is not that simple, that it is not the answer to everything.

The history of science will demonstrate by hundreds of examples how very over-simplified, if not wrong, the common idea about the scientific method is. Intuition, mistakes, trial and error, prejudice, and emotion, all play a bigger role in the history of science than all the scientific method put together. Even chance plays a very important role. It took many meat vendors in the streets of Italy to find by trial and error the method for preventing maggots which gave the clue that led ultimately to much of the work of Pasteur. No one can say that Priestley and Lavoisier were impersonal, nor that the scientific method led to a great truth when it formulated the phlogiston theory. The observation of facts is not easy either. "Facts" led to this phlogiston theory, to the ether theory; they led to Newton's

laws, and to relativity. Observations can be described only when the observer knows what to look for. Furthermore, no one can tell when all the pertinent facts have been found. As Einstein and Infeld express it in their book, "The Evolution of Physics," a scientist is a little like a detective, but the detective at least knows that a crime has been committed, while the scientist must not only look for clues but also for the "crime" about which clues can be found. The scientific method might thus include the fact that someone thinks of an answer first, and then hunts for observations that will prove his point. This is, by the way, a good definition of the meaning of the word prejudice, yet the scientific method is supposed to be free from prejudice.

The popular concepts concerning the scientific method fail to include the realization that this method includes mistakes. The errors, in fact, are often very important for they often lead the way to more fruitful investigation. Upon many false clues and errors the dreamer may base his whole line of reasoning which leads to important discovery. It is often the deviation from what is believed to be true that is the important thing in an investigation. And the word "dreamer" is used wisely, for science requires some dreaming if it is to progress. The man who quits work at five and who does not dream will not be the most apt to produce the results in science. In the same way, an active imagination is important, for it is the imagination that leads to the ideas for new ways to do things.

Finally, I have never seen an article on the scientific method that emphasized the fact that no one man can hope to use all of the so called steps of the scientific method. One man dreams while his graduate students take measurements; another may translate the works of Aristotle, while yet another group tests a false trail, a dead end. It may not be long, or it may be a century before enough men can collect enough information so that some one man may, with the help of revelation perhaps, see the key to it all.

Let us be honest, both with ourselves and with those who may have a chance to read or to hear what we think. The scientific method is not short, nor is it a definite pattern of steps, nor is it easy. It is a mass of people, working in many different fields and in many different ways; it is a mass of mistakes and errors in observation and logic, each hopefully less glaring than the last. These errors that are so much a part of the progress of science mean that the scientific method cannot be applied to just any field; in fact, there are few fields of human endeavor in which such errors are even permissible. Imagine a foreign relations program that exists between nations guided by errors, particularly in our time. The scientific method does not presuppose that the answers will be correct for all time. It does, perhaps,

increase the hopes that, out of a lot of hard work and many man-hours spent chasing will-o'-the-wisps, an occasional answer is found or a spark of truth discovered.

GABRIELSON AWARDED THE LEOPOLD MEMORIAL MEDAL

The Leopold Memorial Medal for service to wildlife conservation, named after the University of Wisconsin's famed conservationist, the late Aldo Leopold, was awarded to Ira N. Gabrielson, Washington, D. C., president of the Wildlife Management Institute, at the annual banquet of the Wildlife Society.

The Wildlife Society is one of the member organizations holding the annual North American Wildlife Conference in Washington, D. C.

Gabrielson is the fourth recipient of the Leopold Medal, which has become a coveted distinction in the field of wildlife conservation since it was founded after Leopold's death in 1948. Leopold was professor of wildlife management at the University of Wisconsin and a world-renowned leader in the field.

Gabrielson was awarded the medal for his outstanding contributions to the field of wildlife conservation from 1915 to the present.

Born in Cedar Rapids, Ia., Gabrielson began his career as a teacher in Iowa schools. In 1915 he joined the U. S. Bureau of Biological Survey and three years later he became a member of the rodent control division, working successively in North and South Dakota, Iowa, and Oregon. In 1931 he became Pacific Coast regional supervisor of rodent and predator control, and later was made game management director for the same region.

In 1935 he was made assistant chief of the division of wildlife research for the U. S. Biological Survey, and shortly thereafter became chief of the survey. He continued in that position through the reorganization of the survey into the U. S. Fish and Wildlife Service and until 1946, when he became president of The Wildlife Management Institute.

Gabrielson is the author of three books, "Wildlife Refuges," "Wildlife Conservation," and with S. G. Jewett, the "Birds of Oregon."

The award was presented to Gabrielson at the banquet by Daniel Leedy of the U. S. Fish and Wildlife Service and president of The Wildlife Society.

Prof. Robert A. McCabe of the University of Wisconsin department of wildlife is chairman of the Leopold Memorial Medal committee. In selecting Gabrielson for the award the committee announced:

"As a federal administrator, he exhibited superb tact and resiliency in defending federal hunting regulations against the determined onslaughts of local and often selfish interests."

Previous recipients of the Leopold Memorial Medal are Jay N. "Ding" Darling, former chief of the U. S. Biological Survey; Carl D. Shoemaker, editor of the *Conservation Report*, publication of the National Wildlife Federation, and Olaus Murie, president of The Wilderness Society.

ANTI-ARTHRITIS DRUGS RESTORE AUTO-SHOCKED DOGS

A dog in shock after being hit by an automobile can be brought back to normal with the aid of ACTH or cortisone, Dr. Peter H. Forsham of the University of California Medical Center says.

These two hormone drugs, widely known for their treatment of rheumatoid arthritis in humans, are also useful for relieving allergic rashes, asthma, and the swelling and inflammation of certain spider and snake bits.

They are useful in the same way, Dr. Forsham finds, for treating such conditions in animals.

THE PLACE OF MATHEMATICS IN SECONDARY EDUCATION*

WILLIAM DAVID REEVE
Professor Emeritus of Mathematics, Teachers College, Columbia University, New York, N. Y.

(Concluded from April)

IV. THE REAL REASONS FOR THE PRESTIGE OF MATHEMATICS

What are the real reasons for the prestige of mathematics in the schools? Why has the subject continued to hold such a high place? The prestige of mathematics has been due in large part to the following:

1. *The wonder motive.* The mystery of the thing or what has been called the "wonder motive." The student becomes interested whether he understands or not, much the same as he reads a book filled with big words for the few things which he can understand. This is what makes the puzzle element of mathematics so vital. Take the puzzle element out of algebra and you will kill it. The wonder motive explains why physics, chemistry, radio, television, and the like are so extremely popular. Such was once the standing of religion. In this sphere the word "proof" is used in an elemental sense. That is, "The proof of the pudding is in the eating."

2. *Tradition.* Mathematics would not have held its place through the wonder motive alone. Tradition has had much to do with the exalted position which mathematics has held. Why, for example, do we wear clothes? Not to keep warm, but, as the sociologist points out, for decorative purposes. Primitive people still do this. The race wore rings at first to preserve the gold that was in them. All such customs are kept alive because of tradition. This is one reason why Euclidean geometry remained practically unchanged for over 2000 years. Tradition, however, is not a sufficient reason for teaching mathematics.

3. *The systematizing motive.* In the third place, mathematics through the course in geometry teaches logic. In fact, it is the only secondary school subject which does. If deductive logic is worth teaching at all, then geometry is the best discovered instrument to use in teaching it. Someone may say why not teach pure logic then? The answer is that geometry furnishes us with figures to illustrate and to reinforce spoken words. I may add that if geometry ever dies as logic has, it will be because we have been teaching at as formal grammar used to be taught.

Fawcett[15] carried on a very interesting experimental study at the

[15] Fawcett, H. P. *The Nature of Proof*, Thirteenth Yearbook, National Council of Teachers of Mathematics, 1938.

University High School at Ohio State University for some years. His problem was to show that one can teach students to think about life problems in geometry in such a way that they are led to understand better the nature of proof.

It is in formal geometry where the "systematic motive" reigns supreme in contrast to the wonder motive which first holds the student's interest and attention in the earlier years of his mathematical experience. Here students do not get interested so much because the propositions studied are so wonderful, but because of the beautiful, well-ordered, and systematic scheme of things. We used to think that we could depend upon the systematizing motive and some teachers are still doing it. However, we have come to the place in this country where we realize that the teacher needs to distinguish clearly between the purpose in teaching informal geometry and the demonstrative type. Perhaps the mathematics professor in college can take the systematizing motive for granted, but the mathematics teacher in high school certainly cannot.

We also have the use of the word "proof" in a legal sense, the "argument that produces conviction." In other words, if on a jury the argument of the defense produces a proof in a person, it is a proof. The proofs that Euclid gave were not addressed to a type of people who were doubtful. If they were, the argument given to them is not of the right sort. This does not mean that the third sense in which the word "proof" is used is futile. In this sense the aim is not to produce conviction but to show logical systematic relationship.

In this last sense of a "proof" assumptions are laid down and all else grows out of these. "Proof" means to arrive at the truth of a proposition not assumed from that which was assumed. The trouble with much of our teaching has been that we have compelled students to prove the obvious. We have said in substance, "Thou canst not know what thou hast not proved"; that the student can take nothing for granted unless he has connected it up with assumptions. This does not mean that we should exclude geometric reasoning when it is needed. Imagine, however, asking a student to prove that *if a point A lies at a point which is greater distance from the centre of the circle than the end of a radius, it lies outside the circle.*

4. *A fine art.* Mathematics is a fine art—a study of harmony, of symmetry. We would not claim, however, that this alone would keep mathematics in a high place. This fact no doubt has more to do with the *way* rather than the *reason* for teaching the subject.

5. *Contribution to a scientific age.* In this complex scientific age in which we live it is only natural that mathematics is sure to play an important part. We can now see mathematics coming into its own in radio, television, aviation, and navigation.

V. Modern Views

Objectives in teaching mathematics. If you and I were to try to show why mathematics should have an important place in the schools, we should probably adopt the modern plan of stating a list of objectives. For, after all, the basic problems in American education "are problems of aim." We should perhaps state the great central purpose in teaching mathematics which is the same in the teaching of any subject, namely, "to develop well educated citizens." We should then formulate a definite list of strictly mathematical objectives. The lack of well-defined objectives is responsible for much of the unsatisfactory teaching of mathematics in the secondary school. But in order to determine our objectives we should be faced with many difficult questions. To illustrate:

1. Once we decide upon what constitutes mathematics we must decide upon the aim in teaching each part. "Nobody can hit the bull's eye if he doesn't aim at it." Are the aims in teaching each part clear to most teachers? I believe they are not.

2. What should be the spirit of your teaching and mine to bring out the nobler thoughts of the students? Of course, in all such cases much depends upon the teaching and where the emphasis is placed.

3. How can we escape what David Eugene Smith called the "dull drudgery" of a proof in geometry? He said that the thing that characterizes the modern trend in secondary education is that we are reaching the souls of the children. I hope we are, but I am at once reminded of the story of the teacher who said, "I keep ringing but I can't get central."

4. Some hypercritic may ask, "Why should a girl study algebra?" A better question would be, "What is algebra, anyway, and why should anybody study it?" Or, for that matter, why not ask, "Why study anything?" "Why study geography?" Presumably it did not help the Parisian nurse who asked one of her American patients which railroad he intended to take from Paris to New York. Why should one study arithmetic? Because he will need it to balance his bankbook. But does it balance?

A few years ago in answering such questions, we should have said, "Because it is our business to develop scholars." But today with everybody going to high school we are not developing scholars in mathematics or in anything else. The most retarded student in the American public school today is the brilliant student or the student of scholarly mind. We would have found this out sooner if we had tested more. We would do well in some places now to begin to evaluate better the teaching of mathematics. But before we can set up an evaluation program that is worth while we must attempt to describe the

kinds of behavior we wish students to exhibit after attending the secondary school that would not be possible except for the training they had received therein.

There is also the aggravated problem of the slow learning students in mathematics. Much has been written about them, but little if anything has been written about what should be done with the slow learning teachers. The students have a right to have teachers who know how to teach and they also have the right to study a kind of mathematics which they not only can understand but can have some joy in learning.

To be sure, most of the critical attacks on mathematics are profoundly silly, but there are real reasons for complaint. The trouble is not so much with the subject as it is with faulty organization and antiquated methods of teaching. On the other hand, the prestige of certain traditional topics is more apparent than real and we need to be more careful and vigorous in modernizing our objectives.

The universal criticism of foreign visitors who observe our American schools is that the work is very superficial. Can we deny that on the whole this is true? On the other hand, they say that we have a spirit here to be found nowhere abroad. Our nation is the first to make a fetish of education. It is only natural that we shall make mistakes. We have two good reasons neither academic nor mathematical for desiring that each normal boy or girl shall graduate from high school. The first is a social one and the second has to do with the safety of the nation. But we should not let these aims mislead us into a false feeling of security. While we should frankly admit the inferiority of much of the human material with which we have to deal, we should not let that admission force us to compromise too much with what is best for the greatest number of the population.

The function of the junior high school. The junior high school should offer an opportunity for making a general survey of the meaning of the great branches of human knowledge. It should not fear to be superficial, for its mission is to show a wide surface rather than a narrow depth. It should be at the same time a period in which interest should be awakened, knowledge extended, and a diagnosis made of the student's abilities and tastes. At its close, each student should have shown his parents, his teachers, and himself, in a rather general way, what is his natural bent of mind and what it will very likely continue to be. If he has no taste for or ability with respect to mathematics, and does not expect to enter a college or a technical school, he should no longer be required to pursue the subject, and similarly with respect to other important branches. His mind has been given its chance, it should now be given a reasonable choice,—a matter to be determined by his parents, his teachers, and himself.

It is not likely to be such as to lead to any narrow specialization in the senior high school, but it is quite possible that it will lead him to cease studying certain special subjects,—say natural science, foreign language, mathematics, drawing, or the manual arts, for which he had no taste and in which he has shown no ability. This does not mean unrestrained license of election or freedom to choose "snap courses"; it simply means that there is little use in continuing in a field in which there is neither interest nor hope, or in attempting to proceed to college when the mind does not permit of laying the necessary foundations.

The mathematics of the junior high school.[16] The following five categories represent what the student should get as an introduction to the general range of elementary mathematics:

1. *Informal geometry.* This means such a knowledge of shape, size, and position as people need to have for purposes of general information.

2. *The application of arithmetic to business problems.* This means that the students should be shown the uses of arithmetic that any well-educated citizen is expected to understand, but not the technicalities of special branches like banking, bookkeeping, or machine-shop practice.

3. *The algebra of the formula, the equation, the graph, and directed numbers.* This means that these four concepts are so important in elementary science, in simple mensuration, and in ordinary business that everyone should know something about them.

4. *The general nature of trigonometry.* This means that all students should have some idea of how distances and heights are measured by this simple device. It does not mean that any of the difficult parts of trigonometry are to be studied.

5. *The significance of a demonstration.* This means that every student should have the privilege of seeing the nature and of understanding the significance of a mathematical proof. This is best done by a few theorems in geometry. It does not mean that the student is to take a difficult course in demonstration, but that he should know the force of the word *demonstrate.*

We must approach the final solution of the problem as scientifically as possible. The organization of the new curriculum should be fundamental and more psychological than the traditional course. In order to do this there are certain important steps in curriculum building which must be kept in mind.

Beyond the work of the junior high school, the course in mathe-

---

[16] Reeve, W. D. "Curriculum Problems in Junior High School Mathematics," *Teachers College Record,* January, 1928, 29: 334–344.

matics should be made elective for those who show ability in mathematics or special need for some of its branches. Such an arrangement of the curriculum would be better for the student than the more traditional one, and much better for those possessed of some native ability in the science. To the select group the call of mathematics is something beyond the physical; it is the call of the soul, precisely as in the case of music, painting, and of the other fine arts, or of science or of letters.

Do the schools teach mathematics at its best? But do we recognize all this in our teaching of the subject? Alas! We recognize so little in our teaching of anything. The greatest need today is for teachers of ability and vision who love children and who can teach mathematics as though salvation depends on it.

The mathematics of the senior high school. The purpose of the mathematics course in the senior high school is to meet the needs of the following four groups of students:

1. Those who intend to go on to colleges and technical schools
2. Those who are going to specialize in commercial work that requires mathematics, especially algebra
3. Those who expect to specialize in science
4. Those who desire to study mathematics further because they like it.

There is no question about the need for mathematical training for the students in the first group above who are going to be engineers, statisticians, actuarial workers, certified public accountants, and the like. Again, the main problem here is one of guidance. If we can be sure that students are on the right track, then we can and should clear the way so that such students can be given not only four years of mathematics but mathematics of a very high order. To permit such students to take less mathematics and waste time in their course by going at the rate of inferior students will be tragic for them and the country as well. The same line of thought follows for those students who plan to go on to college where they will specialize in mathematics and then teach the subject, carry on research, or be applied mathematicians of one type or another.

A second group of skilled workers in business and industry will need to know certain mathematical facts and be able to use certain mathematical skills in the new era that will open up after the danger of war is over. Their work is extremely important, but they will not have to be as highly trained as those in the first group mentioned above. The possible future needs of such a group needs to be studied carefully and a suitable course of study worked out to meet such needs.

A third group consists of those who intend to specialize in science. We ought to be able to assume that for them mathematical training of a high order would be basic if it were not for the fact that it does not work out that way. A careful study of the needs of this group should be made and the necessary content material organized for teaching purposes.

The last and by far the largest group of our citizens will be those who take mathematics because they are made to realize that without a reasonable understanding of the fundamental ideas they will not be competent to carry on as they should. The skills and habits of quantitative thinking must be acquired by such students if they are to meet the reasonable demands placed upon them.

In the new era just ahead many of our students will need to know how to solve the problems of air and marine navigation. This will necessitate an understanding of the facts and processes of algebra, geometry, and at least numerical trigonometry to an extent that will make the offering of at least a two-year course in general mathematics starting with the ninth grade and possibly a three-year course mandatory.

I shall now state what I think would constitute a good course in general mathematics for the secondary school.

The purpose of the course in general mathematics should be to *obtain a vital, modern scholarly course in introductory mathematics that may serve to give such careful training in quantitative thinking and expression as well-informed citizens of a democracy should possess.* It is, of course, not asserted that this ideal can always be attained. Our achievements are not the measure of our desires to improve the situation. The material should include such simple and significant principles of algebra, geometry, trigonometry, practical drawing, and statistics, along with a few elementary notions of other mathematical subjects, the whole involving numerous and rigorous applications of arithmetic, as the ordinary person is likely to remember and to use. There should be an attempt to teach students things worth knowing and to discipline them rigorously in things worth doing.

The argument for a thorough reorganization need not be stated here in great detail. But it will be helpful to enumerate some of the major errors of secondary-mathematics instruction in current practice and to indicate briefly how general mathematics attempts to improve the situation. The following points serve to illustrate its purpose and program:

1. The conventional ninth-year algebra course is characterized by *excessive formalism*, and there is much drill work largely on nonessentials. Such work is greatly reduced in general mathematics and the emphasis placed on those topics concerning which there is general

agreement, namely, *function*, *equation*, *graph*, and *formula*. The time thus gained permits more ample illustrations and applications of principles and the introduction of more significant material.

2. Instead of crowding the many difficulties of the traditional geometry course into one year, geometry instruction is spread over the years that precede the formal course, and the relations are taught inductively by experiment and by measurement. Many foreign schools and an increasing number of American schools proceed on this common-sense basis. This gives the student the vocabulary, the symbolism, and the fundamental ideas of geometry. If he leaves school or drops mathematics, he nevertheless has an effective organization of geometric relations. On the other hand, if he later pursues a formal geometry course, he can work far more effectively because he can concentrate on the logical organization of space relations and the formal expression of these relations. The longer "time exposure" minimizes the difficulties met in beginning the traditional geometry courses and avoids the serious mistake of forcing deductive logic and philosophic criticism in these early years.

3. The traditional courses delay the consideration of much interesting and valuable material that secondary mathematics has to offer, and which may well be used to give the student very early an idea of what mathematics means and something of the wonderful scope of its application. Trigonometry, containing many easy real problems, furnishes a good example of this delay. Other examples are found in the use of logarithms, the slide rule, standardized graphical methods, the notion of function, the common construction of practical drawing, the motivation of precise measurement, a study of the importance of measurement in modern life, and the introductory ideas of analytic geometry and the calculus. The mathematics student should be given an opportunity to use these important tools very early in his study. They lend to the subject a power and interest that drills on formal material cannot possibly give.

Particular emphasis should be given to graphical representation and statistics. The growing complexity of social life makes it necessary that the intelligent general reader possess elementary notions of statistical methods. The hundreds of articles in the current magazines so extensively read demand an elementary knowledge of these things in order that the student may not remain ignorant of the common, everyday things of life.

4. Mathematics needs to be reorganized on the side of method. The information we now possess of individual differences and effective devices in supervised study should make the study of mathematics more nearly a laboratory course, in which more effective work can be done.

5. The teaching of algebra, geometry, and trigonometry in separate fields is an artificial arrangement that does not permit the easy solution of problems concerning projects that correlate with problems met in the physical and biological sciences or the manual and fine arts. To reject the formalism of algebra, to delay the demands of a logical unit in geometry, and to present the simple principles of the various branches of mathematics early in the course opens the door to a greater variety of problems that seem to be real applications. The student thus sees the usefulness of the various modes of treatment of the facts of quantity. Power is gained because the student is equipped with more tools, in that the method of attack is not limited to one field.

While the emphasis at first should be placed largely upon algebra, the emphasis in the later work is placed principally upon geometry. At the same time, however, the earlier work in arithmetic, algebra, and trigonometry is kept before the student by means of reviews and applications, and enough new material is introduced to give to the student that knowledge of the fundamentals of these subjects which he should have at the end of the tenth grade.

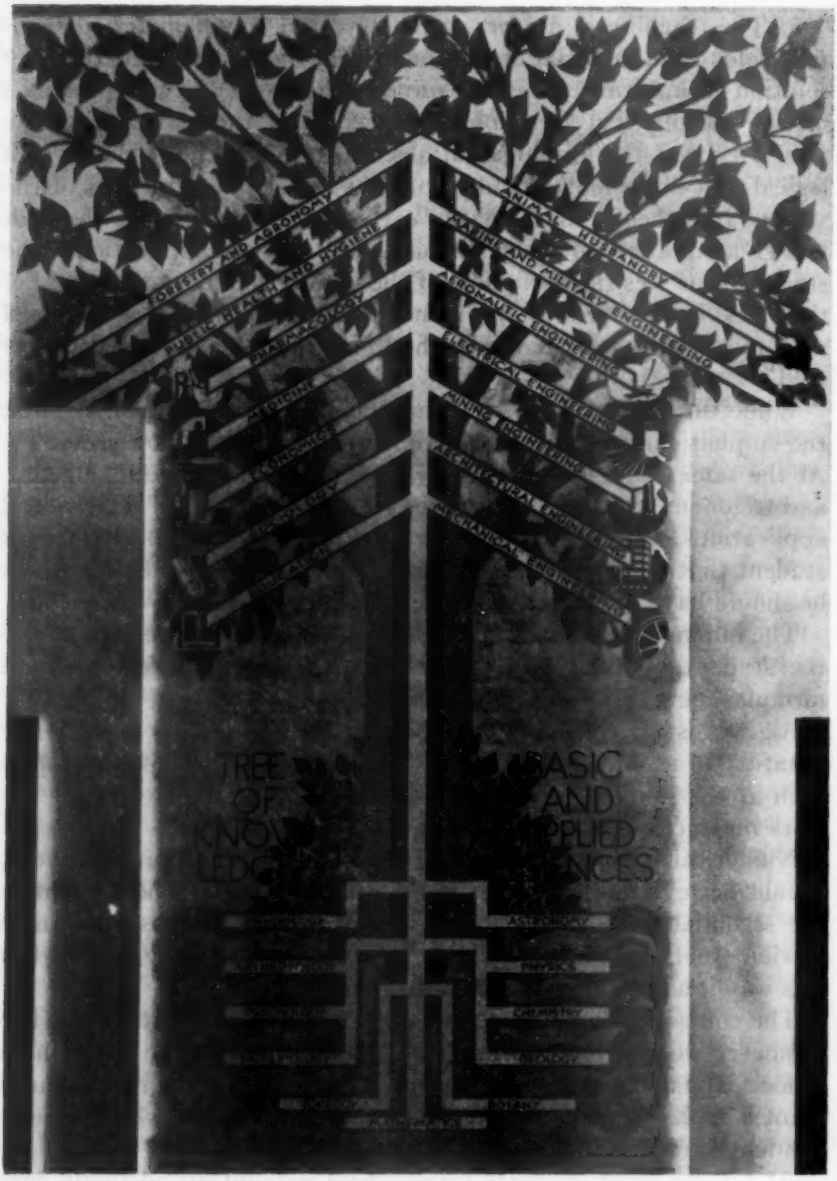
The fundamental laws and operations of arithmetic are kept before the student by their uses in connection with the development of formulas, new topics in algebra, and applied problems.

Algebra is reviewed and extended by the application of algebraic notation to geometric situations, by the introduction of new topics such as the solution of quadratic equations by formula, and by the work on fractions and trigonometric identities.

Numerical trigonometry, which usually begins in the ninth year, should be reviewed and extended in the tenth year. The student in the secondary school has the right to learn how to use this most efficient tool in solving problems, and the trigonometry included in this way is as simple as algebra and geometry.

The course in plane geometry is concluded in the tenth year. The geometry work is more formal than was the case in the junior high school. Thus, the informal experimental type of proof by measurement is replaced gradually by the demonstrative type which is independent of measurement.

At present most students leave school without an adequate conception of the spatial relations about them, and for this reason the fundamental ideas of lines and planes in space are included in the tenth year course in some schools. Plenty of time can be saved for this work by the unification of the various subjects and by the elimination of many topics that heretofore have been included in the different branches of mathematics when taught separately but which are unnecessary and too difficult in a course in general mathematics.



TREE OF KNOWLEDGE

Moreover, many of the propositions of solid geometry are analogous to those of plane geometry and can be easily taught in connection with them. In addition, a simple introduction to the most elementary type of analytic geometry can be given in the tenth year in order that the student may gain some familiarity with the idea of the cor-

respondence existing between an equation and a line of the plane, and may recognize the type of conic represented by an equation of the second degree.

The aim of the general mathematics course is to give the student *not so much mathematics* as is generally given in the traditional courses, but *more about mathematics*. In other words, the student should know mathematics as a tool to be used rather than as a group of related subjects, such as algebra, geometry, trigonometry, and so on. With such an aim it has been possible to arrange the general mathematics course so as to make unnecessary the long tedious reviews that are so often given in traditional courses, and to save the time thus spent for the introduction of new and interesting material. Throughout the entire course a special effort is made to impress the student with the various uses that are made of mathematical laws and principles in everyday life, and many exercises which show the practical uses of geometry are included.

For the students who continue to study mathematics, they should be given the type of course that should be offered in the eleventh and twelfth years where intermediate algebra, trigonometry, analytic geometry, and the fundamental elements of the calculus are correlated.

In the fields of business and industry where the threat of war has created new problems different emphases may have to be made particularly where some of these problems of war come to be also the problems of peace in the days ahead.

Let us also hope that more and better prepared teachers will be available and at salaries that will enable them to make a decent living. No matter what happens, however, we should not expect miracles and it is clear to those who understand the present situation that in many places better teachers, higher salaries, and more money for better books, equipment, and the like may not be forthcoming, although we hope so.

In any case, teachers who remain in the classroom because they want to do so in spite of handicaps must somehow learn to teach in better and more interesting ways many of the things that are now in the course of study. This need not be discouraging, for this can be done if, and only if, teachers are inspired to carry on the work as outlined by the commissions and committees which have tried so hard to help.

The tree of knowledge. In the Hall of Science at the Century of Progress Exposition in Chicago there was a large mural representing the "Tree of Knowledge," a reproduction of which is shown below.[17] As

[17] Copies of this mural suitable for framing or for pasting in the students' notebooks (size 6"×9") may be obtained postpaid from *The Mathematics Teacher*, 1201 Sixteenth Street, N.W., Washington 6, D. C., for 5¢

can be seen from the picture, mathematics is the foundation and the vitalizing energy for the basic sciences such as astronomy, botany, chemistry, geology, and physics and together with them furnishes strong support for the applied sciences in the higher branches, such as the social studies like economics and sociology, and engineering of various kinds. A copy of this mural should be hung in every mathematics classroom.

The fact that mathematics is so important is not surprising to one who is properly informed with respect to the contributions mathematics has made to the other great fields of knowledge and to civilization, but many citizens, including a number of educators, are still unaware of the strategic place mathematics really occupies in world affairs today. It should be the business of those of us who are interested primarily in mathematics to help make clear just where and how mathematics can be of real sercice, and what can be done to secure this service by teaching mathematics better in the secondary school.

---

each or 50¢ per dozen. Larger copies for the classroom 25"×38" in colors may be obtained for 30¢ each postpaid from the Business Manager of *The Museum of Science and Industry*, Jackson Park, Chicago, Illinois.

CLAMS DON'T "CLAM UP"; GIVE UP SCIENTIFIC SECRETS

The clam has always enjoyed a reputation for reticence—but now it is giving up secrets of considerable interest to science.

So says Dr. K. P. Rao, marine zoologist from India who is doing research at the University of California at Los Angeles on the "living rate" of shellfish. He defines living rate as "the efficiency in utilization of elements taken in by the animal."

Dr. Rao has found that clams live "faster" at high tide than at low tide and that this variation continues at periods corresponding to tide levels even when the clam is placed in a laboratory aquarium.

He has also found that clams live "faster" at lower depths than nearer the surface and that northern clams live "faster" and have thicker shells than those in southern waters.

The variation in living rate with tide levels is still somewhat of a puzzle. One theory is that clams become conditioned to changes in water pressure due to the tides, and this response continues regardless of environment.

There is, however, a clue to the shell thickness differences. Clams can take in calcium, much of which is deposited in the shell, directly from sea water, It is known that calcium ions are more available in cold water than warm water. Perhaps for this reason the colder the water the thicker the shell, says the Indian zoologist.

New refrigerator freezes ice "cubes" without trays and stores them in a basket, automatically replacing them as they are used. Actually crescent-shaped bits of ice, the "cubes" are said to be drier than the ordinary ice cubes and will not stick together in the storage basket.

REGIONS OF VULCANISM

JAMES K. ANTHONY
Southern University, Baton Rouge, Louisiana

Attention is called to the frequency in which the newspapers have been reporting new volcanic eruptions throughout the world. Within a three-month period, from June to September, 1952, no less than three new volcanoes have had their beginnings—Didicas, off the coast of the Philippine Islands; and two un-named volcanoes, one located about two hundred miles from Tokyo and the other just off the west coast of Mexico. Recently the crater of Hawaii's Halemaumau has begun to attract visitors and to arouse the interest of vulcanologists, for this volcano is in eruption again, its first in about eighteen years.

Intimately associated with volcanic phenomena are earthquakes and California has been experiencing some destructive tremors recently. These seismic disturbances should bring no surprise to those who are familiar with the regions where vulcanism occurs. The distribution of volcanoes is world wide. Every major continent can claim at least one active, quiescent or extinct volcano. In addition there are those subaqueous cones of the oceans whose locations are known either by the appearance of their craters above sea level or the later disappearance below sea level.

There are two major and one minor regions of vulcanism. The "Pacific Ring of Fire," a circum-Pacific belt begins at Tierra del Fuego and extends along the lands that border the Pacific Ocean. An east-west belt starting in the Lesser Antilles of the Caribbean Sea and extending across the Atlantic Ocean to include the Azores, Canary, and Cape Verde Islands; the Mediterranean Sea (with branches extending southward to the Rift Valleys of Africa and northeastward to include Asia Minor) and then along the southern coast of Asia terminating at the union of the Pacific belt in the Netherlands East Indies. The minor volcanic region is that one which begins in Greenland and extends eastward through Iceland and terminates in Siberia. Of the four hundred or more active volcanoes in the world most are located in the circum-Pacific belt.

The materials deep within the earth are very hot but do not exist in a liquid state because the pressure of the surrounding rocks is so great that the molten rock actually is in a state of plasticity and becomes liquified only when the surrounding pressure is lessened. This, of course, may occur through the radioactivity of the rocks or through diastrophism. Once magma has been formed its ascent to the surface of the earth may be achieved (1) through its chemical action on limestone rock, liberating carbon dioxide which is easily pushed to

the surface; (2) the weight of the overlying rock which may squeeze the magma upward through fault lines; and (3) as the reduction of pressure occurs magma rises nearer to the surface of the earth.

The degree of volcanic explosiveness may be due, in part, to the physical condition of the magma. A volcano that exhibits a very fluid magma and there is little violence accompanying the liberation of gases is called the *Hawaiian-type*, as the Hawaiian volcanoes show this type of behavior. If the magma is less fluid and is associated with violent explosions and the ejection of dust, pumice, scoriae, and rocks, the volcano is the *Strombolian-type*. A volcano in eruption which ejects great masses of rocks, dust, and gases is the *Vulcanian-type*. The most violent and destructive of volcanic eruptions is the *Peleean-type* which is characterized by sudden destruction of life and property because of gusts of fire and asphyxiating gases.

The Pacific Ring of Fire

The volcanic peaks of the Andes do not form a continuous range of mountains but are separated into three groups. The southern group is located in central Chile and western Argentina. Mt. Aconcagua, approximately 22,884 feet high, is the most outstanding peak in this area. Chile, however, does not mark the end of the line of volcanoes, for Mt. Corcovado in the Patagonian Andes rises to 7,510 feet above sea level and Mt. Sarmiento in Tierra del Fuego is approximately 7,200 feet high. Other volcanic peaks of this region are: Llullailaco, Cerra del Mercedario, Tupungato, and San Jose. The volcanoes from central Chile southward are extinct.

In the middle Andean region of Southern Peru and Northern Chile, El Misti, 19,167 feet above sea level, is the only volcano of this region that still retains a symmetrical cone. No eruptions of El Misti have occurred since the days of the Spanish conquest though wisps of smoke float lazily upward from its crater which indicates a period of dormancy or quiescence.

In the Northern Andean group of southern Colombia and northern Ecuador rises Mt. Cotopaxi 19,498 feet above sea level. Cotopaxi has frequently been described as having a cone as beautiful as Mt. Fujiyama in Japan. From Quito, 35 miles south-southeast, Cotopaxi can be seen though most of the time its peak is hidden by clouds. The city of Tacunga was destroyed along with three-fourths of its inhabitants during the eruption of Cotopaxi in 1698. Destructive eruptions occurred in 1738, 1742, 1744, 1766, 1803, and 1877. During the early days of August 1949, some mountain towns south of Quito and in the vicinity of Mts. Chimborazo and Cotopaxi were either damaged or destroyed because of intense seismic activity. Landslides re-

sulting from the earthquakes caused Tungurahua volcano to erupt killing many persons.

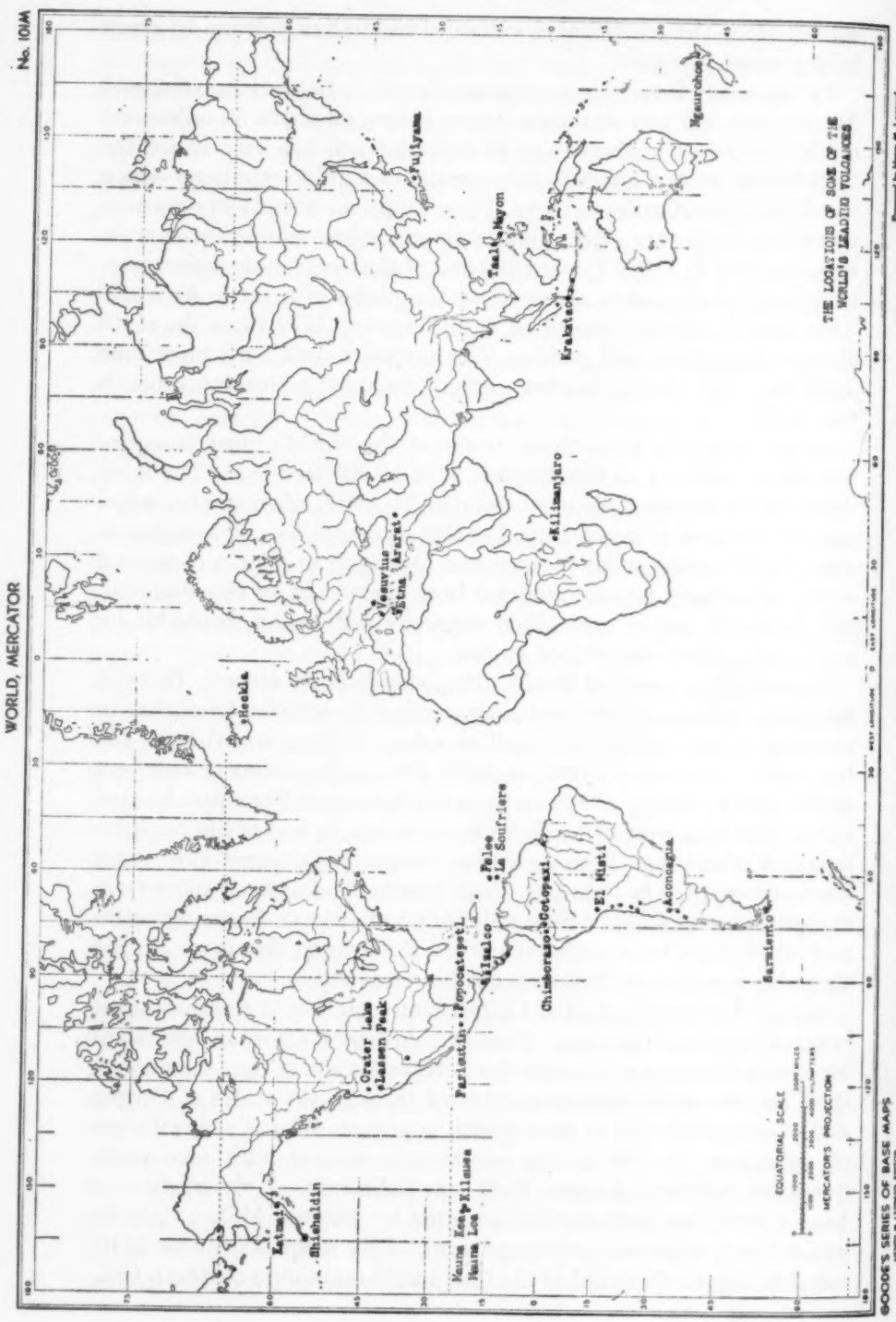
Of the many interesting volcanoes found in Central America and Mexico four will be mentioned. Izalco is located about 30 miles west of the city of San Salvador in El Salvador and has been called the "lighthouse of the Pacific" because of its regular eruptions which can be seen for 20 miles or more. These eruptions have been occurring approximately every eight minutes since the first subterranean noise was recorded in 1769. Toward the end of that year more noises were heard and earthquakes occurred on the plains of a cattle *hacienda*. This seismic activity continued until February 1770 when the earth ejected lava, dust, and pumice. The extrusive rock built up a cone 2,000 feet high. Izalco has been one of the most active volcanoes in the world.

Santa Maria, in Guatemala, is one of the world's most beautiful volcanoes and just as destructive. It is 12,363 feet high. The most devastating eruption occurred October 24, 1902, when ejected ashes covered an area of more than 125,000 square miles. In a region of some 2,500 square miles pumice and rocks fell to depths of several inches and many houses collapsed from the weight of this material. Six thousand people were killed either by suffocation, being hit by rocks, or by the collapsing of houses.

Several miles south of Mexico City, stands Popocatepetl. This is a quiescent volcano 17,880 feet high varying its activity from that of emitting smoke to that of expelling ashes, cinders, and stones. The last major eruption occurred in 1540. One of the youngest members of the world's family of volcanoes is the 1,000 foot Paricutin, located about 200 miles west of Mexico City. Though no loss of life has been reported, there has been extensive property damaged ever since Paricutin erupted in February 1943. Vegetation has been killed from the volcanic ash and the little village of San Juan de Parangaricutiro and others have been buried under the slowly engulfing lava. During the subsequent years Paricutin has been less active.

Zones of vulcanism in the United States are found along the west coast. From the Tehachapi Pass in southern California northward for over 430 miles extends the Sierra Nevadas where they merge with the Cascades and continue northward through the states of Oregon and Washington. These geologically young mountains showed signs of vulcanism as late as the nineteenth century with one quasi-quiescent volcano, Lassen Peak, in California. A description of Lassen Peak has been poetically stated by Joaquin Miller: "Lonely as God and white as a winter moon." This steep-sided cone is located at the southern end of the Cascade Mountains in northern Cali-

UNIVERSITY OF MICHIGAN LIBRARIES


No. 10M
WORLD, MERCATOR
THE LOCATIONS OF SOME OF THE WORLD'S LEADING VOLCANOES
Fujiyama
Tarawera
Krakatoa
Mauna Loa
Kilimanjaro
Vesuvius
Etna
Ararat
Hekla
Pelee
La Soufriere
Popocatepetl
Orizaba
Colima
Chimborazo
Cotopaxi
El Misti
Aconcagua
Tarumiro
Crater Lake
Lassen Peak
Parinitin
Mauna Kea
Kilauea
Iztaccihuatl
Shishaldin
EQUATORIAL SCALE
MERCATOR'S PROJECTION
GOODE'S SERIES OF BASE MAPS

fornia and is 10,453 feet high. The advanced state of weathering of the slopes and crater of Lassen Peak suggested volcanic inactivity for thousands of years. But on May 30, 1914, the volcano became active and within the next few years hundreds of eruptions of dust and cinders occurred. During an eruption of 1915, steam mixed with ashes descended the mountain. For ten miles this torrent of hot mud and rocks destroyed forests and beautiful valleys. Mt. Lassen became quiescent in 1917, reducing its activity to hot springs, fumaroles, and solfateras around its peak. Its crater still gives off steam occasionally.

Investigations suggest that the crater of Mt. Mazama was not formed through eruption but by collapsing. Fifteen cubic miles of unaccounted for volcanic debris prompted J. S. Diller[1] to propose the above theory. The process of engulfment may not have been a rapid one but the end result was a crater. Today in southwestern Oregon, this crater atop Mt. Mazama, and popularly known as Crater Lake, contains a lake and is considered ideal for trout fishing. Two forested spines, *Phantom Ship* and *Wizard Island*, protrude above the surface of the lake. Except for the water, this may well have been the setting of the crater of Mt. Vesuvius prior to 79 A.D.

The most outstanding landform feature of Alaska is its mountains. They are principally folded and twisted sedimentary rocks with igneous intrusions found largely on the Alaskan peninsula and on the Aleutian islands. It was Mt. Katmai, located near the base of the Alaskan peninsula, that burst into eruption during the early days of June 1912. No one was aware of what was actually happening until volcanic dust began to fall over northwestern North America. Aside from the devastation in the immediate region of Katmai, pumice fell to a depth of a foot at the town of Kodiak one hundred miles away. Dust even fell in southeastern Alaska 900 miles away. The eruption of Katmai was not accompanied by lava flows but instead thousands of fumaroles were formed within a depression four miles wide and twelve miles long. This is called the *Valley of Ten Thousand Smokes*. E. G. Zies[2] found the temperatures of these fumaroles ranged from 97° to 645°C. In 1917, a fumarole was found to have a temperature high enough to cause mercury to boil but two years later the temperature had cooled considerably.

The Hawaiian Islands in the Pacific Ocean are one large series of volcanic peaks. These islands are composed of a series of cones uplifted from the sea bottom through marine deposition and through volcanic action. Along the slopes of the extinct Lanai, 59 miles south-

[1] Diller, J. S., "The Volcanic History of Lassen Peak," Dept. of the Interior, Washington, 1918, p. 2.

[2] Zies, E. G., "Hot Springs of the Valley of Ten Thousand Smokes," *Journal of Geology*, vol. 32, no. 4 (1924) p. 303 *et seq.*

east of Honolulu, fossiliferous marine sediments are found at a height of 1,070 feet. The lava from the Hawaiian volcanoes is very fluid and much destruction occurs when *pahoehoe* and *aa* descend the slopes of the mountain sweeping away forests and villages in their path. Mauna Loa on the island of Hawaii is sometimes called the "monarch of modern volcanoes." It is 13,680 feet above sea level and from the surface of the water the island containing this volcano extends 18,000 feet down to the floor of the Pacific Ocean, thus making it the second highest peak in the world, extinct Mauna Kea being 104 feet higher. Lava seldom escapes from the crater, instead it finds exit through many fissures around the slope. Kilauea, 4,090 feet high and located 22 miles from Mauna Loa, is the other active volcano of Hawaii. The level of the lava in the cauldera fluctuates. Sometimes it overflows the rim and devastates the countryside; at other times it withdraws within the conduit and does not reappear for many years. The third volcano on Hawaii is Mauna Kea. Snow covers the upper slopes of this 13,784 foot extinct cone while the natives grow coffee on its fertile lower slopes.

Of the many volcanic peaks in Japan, three are worthy of mention. The northern and southern parts of the Japanese island of Honshu are separated by a depressed zone, the *Fossa Magna* of Naumann which extends from the Pacific Ocean to the Sea of Japan. It is along this depression that Fujiyama, 12,461 feet high, is located. This sacred mountain of Japan has been extinct since November 1707, but long dormancy is never an indication that a volcano is extinct and it may burst into violent activity at any time. This is illustrated in the following case.

Bandai-san, located about 180 miles from Yokohama, was considered an extinct volcano. Its 2,000 foot high cone had been dormant for a thousand years. No one gave much attention to the presence of the hot springs along the slopes. But suddenly on the morning of July 15, 1888 seismic activities began, followed immediately by the ejection of dust and steam to a height of 4,000 feet. The last explosion hurled mud, scalding steam and red hot ashes into the valley below. This eruption lasted less than 2 hours; there was no lava ejected and Bandai-san has been inactive ever since. It is believed the percolation of ground water into the volcanic interior formed steam and exploded when the pressure became great.

Sakurajima is a small volcanic island located at the southern tip of Kyushu, in Kagoshima Bay, Until the year 1914, some 18 villages were clustered around the base of this 3,506 foot peak. Orange groves were interspersed with patches of radishes. The terraced hillside produced sugar cane. Junks and sampans dotted the bay. Then from

January 10 to 12, 1914, four hundred seventeen earthquakes were recorded at the Kagoshima observatory. During this time there was a mass evacuation of people from the island to the city of Kagoshima across the bay. On the morning of January 12, a violent explosion occurred sending skyward a gigantic black cloud of dust and destruction. However, the casualties were only about 250 persons!

The Philippine Islands with their combination of folded, faulted and igneous peaks boast of at least 20 active volcanoes of which two are of interest. Mayon, located on Luzon in the province of Albay, is 7,943 feet high. The mountain itself is almost a perfect cone. At its base are fertile plains. Along its slopes grow grasses and mosses. Near the top sulphurous fumes are emitted while the summit is surrounded by gases which are incandescent all through the night. An eruption of Mayon in the nineteenth century completely destroyed Cagsaua at its base. Another eruption occurred on June 23, 1897. Forty miles south of Manila on an island in Lake Bombon rises Taal, 1,050 feet high. This volcano is famous for its many eruptions in the past and for the sulfur deposits at its base.

Rated as one of the greatest explosions of all time, Krakatao's eruption was truly spectacular. The volcanic island upon which Krakatao was located is in Soenda Strait between the islands of Java and Sumatra in the Netherlands East Indies. The island was uninhabited even though Krakatao was considered extinct. On May 20, 1883 this inactivity ceased and minor eruptions began accompanied by loud detonations that could be heard in Batavia, 100 miles away. Then came a lull in activity for fourteen weeks and on Sunday August 26, 1883, Krakatao settled down to completing the job of self-destruction. First, it became concealed behind a thick cloud of black smoke. Violent eruptions of volcanic ash ascended 15 miles. Then on Monday four explosions occurred. They shook the earth, the third one being the most catastrophic. Following this a series of giant sea waves, starting at Krakatao and sweeping outward, destroyed lives and property on the nearby islands. Ships were washed miles inland; natives were washed miles out to sea. Others were killed by being smashed against buildings and trees that withstood the impact of the waves. Fine dust from the explosion circled the earth for a year and brilliant twilights were seen all over the world. In 1927 minor submarine volcanic activity elevated a small island over the spot where Krakatao had been.

The story of Ngaurohoe might be written as *the case of the polite volcano*. Before an eruption, which occurs at intervals of 3 to 4 years, smoke rises to great heights from this New Zealand incandescent crater. The eruptions have seldom been violent nor are there large

lava flows. However, Whakari has not been so considerate. Off the northeastern coast of North Island in the Bay of Plenty rises this volcanic island. Captain James Cook, during his south Pacific explorations, was the first white man to see Whakari. The gypsum that is ejected from the crater gives the slopes of this cone a white appearance. Cook named it *White Island*, but the New Zealand Maoris have called it *Whakari* (meaning: *suspended from heaven by a white cloud*). Because of the prevalence of sulfur in its crater and along its clopes, Whakari has been a center of sulfur extraction until the year 1914 when the volcano erupted, killing all of the employees of the sulfur works.

The East-West Belt

Much activity has occurred in the east-west belt of vulcanism. A mild eruption of ashes, mud, and sulphurous fumes occurred in August 1856 from Mt. Pelee. This 4,429 foot mountain was located at the north end of the island of Martinique in the Lesser Antilles. After this eruption, Pelee was regarded as practically extinct. But on April 23, 1902, an ominous cloud of smoke rose from its crater accompanied with a shower of ashes and cinders. On May 5, scalding mud and lava poured down the slopes causing considerable destruction to life and property. Then a thunderous flash of fire from Pelee on Thursday morning May 8, wiped out the town of St. Pierre. In that single wave of fire 30,000 persons were cremated!

The volcano, La Soufriere, may be called *the arch criminal of genocide*. This 3,822 foot mountain is on the Caribbean island of St. Vincent. Synchronously with Pelee's eruption, La Soufriere, on May 7, 1902, belched forth six streams of lava that flowed down the mountainside uniting in a network and killing everything entrapped therein. The sulfur fumes took its toll of lives even before the lava reached the bodies. Practical extinction of the Carib Indians who lived on this island was assured with this eruption.

On July 8, 1949, Mt. Pelada, located on La Palma, one of the Canary Islands, burst into eruption ejecting flames and lava. This volcano was active for nine days. Seven miles southeast of Naples, rises Mt. Vesuvius. Surrounding Vesuvius can be seen traces of the crater of the older extinct Monte Somma. The height of Vesuvius is 4,000 feet above sea level. A long period of dormancy was broken when Vesuvius erupted in 79 A.D., burying under ash and boiling mud, the cities of Pompeii and Herculaneum and their inhabitants. During the eruption of 1631, lava from Vesuvius destroyed several villages killing 18,000 persons. Vesuvius is the only active volcano on the continent of Europe and there is no indcation that its activity is lessening.

La Solfatera is a cone near Naples whose last eruption was in 1198. Its activity has since subsided to a state of emitting steaming sulphurous vapors. This dying state of a volcano is known as the *solfateric stage*. Throughout the Phlegraean Fields near Naples are subterranean caverns, through which volcanic gases collect. The famous *grotto del cane* has been a death trap for small animals seeking shelter therein. Just north of Sicily are the Lipari Islands which contain two active volcanoes. Stromboli has been active as far back as recorded history. Intermittent eruptions have given to this volcano the title of *the lighthouse of the Mediterranean*. Vulcano has been active long before the Christian Era and still breathes sulphurous fumes. This volcano is also located in the Lipari Islands.

Mt. Etna, on the island of Sicily, has been quite destructive. Sometimes the eruptions of Etna alternate with those of Vesuvius and at other times they are synchronous. In the year 1169, Mt. Etna destroyed the city of Catania with its 15,000 inhabitants. In 1669, some 20,000 people perished from renewed activity of Etna. As late as 1928, lava flows reached the sea after traveling down the 10,870 foot slope at a speed of 20 feet a minute.

Mt. Kilimanjaro, in Tanganyika, has recently showed signs of minor activity. In 1900 an investigation reported no signs of fumaroles or solfataras anywhere near the mountain. In 1943 it was reported after an ascent to the top of the cone that the rocks were warm. There were fumeroles and deposits of sulfur in many places. The Armenian plateau in Asia Minor reaches its culmination in Mt. Ararat some 17,000 feet above sea level. This extinct volcanic peak is the site that the Ark of Noah was supposed to have rested after the Deluge.

Some Minor Areas

Ever since the ninth century when Iceland was populated about 27 volcanoes have been active. The most famous of these is Heckla. This 5,100 foot peak is 20 miles from the southwestern coast of Iceland. Twenty-six eruptions have occurred since the 11th century. Many have been of long duration and quite violent. The eruption of September 1845 lasted for over a year and volcanic ash and dust fell on the Orkney Islands, 500 miles away.

Submarine volcanoes in the making are known by the disturbance seen on top of the water. Dead fish, pumice, cinders, and steam may come up to the surface of the water. Following this an island may appear. Graham's Island located between Sicily and the coast of Africa, came into being in 1831. Rapid erosion, however, reduced it to a shoal three months later. Christmas Island in the Indian Ocean appears to be of volcanic origin. Three small islands south of the Bonin

Islands in the Pacific Ocean are volcanic mountains. Known as the Magellan Archipelago, these islands are called Kito-iwo-jima (Santo Allessandro), Iwo-jima (Sulfur), and Minami-iwo-jima (Santa Agostino). The summits of these islands vary from 2,000 to 3,000 feet.

Economic Aspects of Vulcanism

Since the negative or ill effects of vulcanism have been mentioned what, then, are some of its good points? The soils around the base and slopes of Mt. Etna, in spite of its ever-menacing presence, are fertile, so fertile that upwards of five crops a year can be obtained. The regur of the Deccan Plateau of India is so rich that the world's second largest cotton-growing region is located there. And at the base of Popocatepetl in Mexico, oranges, bananas (notoriously famous for exhausting the soil), palms and mangoes are grown.

Japan ranks as the world's third leading sulfur producer. Much of it comes from the western slope of *Siretoko-Iosan* or Sulfur Mountain where the sulfur erupts in a liquid state. Sulfur is also mined at the base of Vulcano in the Lipari Islands. There is a close association between regions of vulcanism and mining areas. For example, gases from Vesuvius during eruptions contain copper, iron, and lead. Upon cooling these form hematite and galena. And when these gases, seeping through fissures cool, the metals solidify forming veins within the rocks.

Construction blocks are formed as a result of magmatic solidification. Many of the buildings of Arequipa, Peru are contructed from *sillar*, a gleaming white rock from the eruptions of El Misti. This is a durable but easily-cut rock. Granite is a popularly-used building rock, too. The frothy, sponge-like rock, pumice, has many economical uses as abrasive materials, filtering and scouring agents, fillers, and surfacers. Iceland has many subterranean springs of hot water. At many places these springs bubble up to the surface of the earth and many Icelanders pipe these hot waters into their homes. But whether or not these springs are *shadows of forthcoming volcanic events*, it is hard to say.

Summary

The regions of volcanic activities seem to be definitely known and eruptions occur in these zones. Fumaroles, solfateras and occasional hot springs at the base of mountains give a clew as to the probable conditions existing within the earth. Magmatic changes usually cause tremors on the surface of the earth and the intensity of the seismic disturbances determines the degree of structural damage. Movement of rock along the San Andreas fault lines in California has caused great

damage and distress to man. And yet man is not entirely the loser for, as a result of volcanic action, he enjoys enrichened soil, and in many areas, mining activities.

Bibliography

Atwood, Wallace W., "The Glacial History of an Extinct Volcano, Crater Lake National Park," Annual Report of the Smithsonian Institution, 1934–35, Government Printing Office, Washington, 1936.
Coleman, Satis, N., "Volcanoes New and Old," John Day Co., New York, 1946.
Coulter, John W., "Geological and Ground Water Resources of the Islands of Lanai and Kahoolawe," *Geographical Review*, vol. 32, 1942.
Diller, J. S., "The Volcanic History of Lassen Peak," Department of the Interior, Government Printing Office, Washington, 1918.
Fenner, Clarence N., "The Katmai Region, Alaska, and the Great Eruption of 1912," *Journal of Geology*, University of Chicago, Chicago, vol. 28, no. 7, 1920.
Finch, R. H., and Anderson, C. A., "The Quartz Basalt Eruptions of Cinder Cone, Lassen Volcanic National Park, California," *Publications in Geology*, University of California, Berkeley, vol. 19, no. 10, 1930.
George, Russell D., "Minerals and Rocks," D. Appleton-Century, New York, 1943.
Hinds, Norman E. A., "Geomorphology," Prentice-Hall, New York, 1943.
Jaggar, T. A., "Volcanoes Declare War," Paradise of the Pacific Press, Honolulu, 1945.
Longwell, Chester R., and others, "A Textbook of Geology," Part 1, John Wiley and Sons, New York, 1932.
McCune, Shannon, "An Eruption of Molten Sulphur in Japan," *Geographical Review*, vol. 32, 1942.
Niggli, Paul, "Ore Deposits of Magmatic Origin," Thomas Murby, London, 1929.
Pough, Frederick H., "Paricutin Is Born," *Natural History*, American Museum of Natural History, New York, vol. 52, October 1943.
Trewartha, Glenn T., "Japan, a Physical, Cultural, and Regional Geography," University of Wisconsin Press, Madison, 1945.
Zies, E. G., "Hot Springs of the Valley of Ten Thousand Smokes," *Journal of Geology*, University of Chicago Press, Chicago, vol. 32, no. 4, 1924.

VISUAL AIDS FOR TEACHING CHEMICAL INDUSTRIAL PROCESSES

A. A. Himmel
Bridgeton High School, Bridgeton, New Jersey

In teaching chemistry it has been recognized that diagrams of the various industrial processes were adequate only in a select few texts. Such a situation is of especial significance in high school chemistry where a single text is the usual procedure, and it therefore falls to the teacher to carefully select textbooks so as to include both subject matter and good diagramatic material. In many cases this is not possible, and it then becomes necessary to supplement the text with an appropriate means of illustrating these processes.

Excellent results may be achieved by means of still slides. A second possibility which may be used to better advantage consists of a set of photographic enlargements made from a selected series of good diagrams.

Selection of Diagrams

After considerable study of the available texts on general chemistry at the high school and college level, it was found that Brinkley's *Course in College Chemistry* offers the most appropriate selection of diagrams suitable for photographing. Lempkin's *Survey of Chemistry* also provided several suitable diagrams. In selecting material to be photographed three factors must be borne in mind; is the diagram included in the course of study, is the process covered in the text used, and is the diagram printed so as to make reproduction possible.

Preparation of the Negatives

Having selected a set of diagrams to be photographed the question which next arises is what materials are required to make the photographs. Copying, as this type of photography is called, is best done with a camera having a double extension bellows and a ground glass viewer. In lieu of such an apparatus it will be necessary to provide a copying lens and a piece of ground glass to be used in conjunction with any standard camera. Acceptable work may be done even with a box camera and the above equipment.

In taking the actual picture the most difficulty is encountered when attempting to fix all of the diagram within a single plane without defacing the text from which it is being taken. One method found to be satisfactory consists of clipping the pages to the cover by means of heavy duty clip type paper clips. The book was then mounted in a stationary position, and the focusing and photographing completed without once moving the book.

The question of exposure time is best determined by means of an exposure meter; however, it may be necessary to compensate for the type of film used, generally process film, since speed ratings on process films are not standardized. An exposure of three seconds at f-11 on process film with one small photoflood lamp diffused and at six feet yielded satisfactory results.

The exposed negatives may be processed either by the photographer or by any commercial house.

Advantages of Diagram Photographs

The negatives once prepared are permanent, and if properly handled may be used for at least five years to provide classes with diagram material. The prints so provided should become the perma-

nent property of the individual student, and should be incorporated into his notebook as a ready reference. It is also possible to prepare a set of direct positives from the negatives and thus supplement the diagram prints with a set of diagram slides.

The cost of making the individual negative will, of course, vary; but in the case of 9×12 cm. cut film, which has a maximum cost, the cost runs less than twenty-five cents. The prints of such a size negative should run about five cents each. The total cost for a class of thirty would then run less than $15.00.

The greatest advantage of distributing such prints lies in the ability of the student to take notes directly on the print. For this reason the prints should be made on matte paper, double weight, on which pencil writing is possible.

It has been found that these diagrams make a more lasting impression upon the student, and enables him to know what processes the instructor considers most significant. For this reason the material must be edited critically by the instructor, and a good description should be provided both in the assigned text, and the class lectures. A list which might be suggested includes:

1. The Frasch Process
2. The Lead Chamber Process
3. The Electric Refrigerator
4. The Haber Process
5. The Contact Process
6. The Vorce Cell
7. The Blast Furnace
8. Open Hearth Furnace
9. Bessemer Converter
10. Viscose Process

This listing is purposely brief since it is felt that too great a number of diagrams will detract from the effectiveness, and would certainly exceed a nominal cost.

EASTERN ASSOCIATION OF PHYSICS TEACHERS
ONE HUNDRED EIGHTY-FIFTH MEETING

Joint Meeting
with
NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS

Saturday, Oct. 18, 1952

St. Paul's School, Concord, N. H.

10:00 A.M. Greetings, Henry C. Kittredge, Rector

10:15 A.M. "Chemical and Physical Aspects of Industrial Tanning," K. A. Blaine, Chemist, Manchester N. H. Tannery, International Shoe Co.

11:15 A.M. "Some Views on Science Teaching Today," Richard D. Wells, Research Director, Bates Manufacturing Company, Lewiston, Maine

1:00 P.M. Luncheon

2:00 P.M. "Some Aspects of Industrial Electronic Controls," E. C. Thomson, Design Engineer, Photoswitch Inc., Cambridge, Mass.

There was a substitution in the third speaker of the day in the form of a fine demonstration of the nature and properties of the ultra short radio waves. The apparatus used is not easily available and for that reason there is no report. The speaker was Dr. Karl Woodcock, Head of the Physics Dept., Bates College, Lewiston, Maine.

SCIENCE EDUCATION

R. D. WELLS, *Director of Research, Bates Manufacturing Company*

Science education for industry is no different than science education for anything else. Because Mr. Wells believes this to be true, he has changed the title of his talk to: "Science Education for Anything and Everything."

"First I shall talk about objectives." We shall deal with the "Why's" now and later the "How's" and "Wherefore's." First, there is "need to stretch and diversify the curriculum. Science subjects help keep youth busy with relatively harmless activities during that difficult period when their glands have stolen an extra lap on their senses. One can only go so far and reach so many with the banana countries, Gettysburg, Silas Marner, football, and the socially acceptable French verbs. Some of the others must be diverted by burettes, prisms, equations, and frogs."

Second, science helps shape the all-round man. The all-round man "has perception for, appreciation of, and perspective on, many things." The blast of the factory whistle not only means the pulsating column of steam but also the urgent call to servitude. He is objective and subjective conscious.

Third, science education has to do "with prestige in the battle of the sexes, and the battle of the generations." Eve, it was, who first had the taste for the fruit of knowledge. It was Adam's idea that no girl is to outsmart me. Since this first experiment, man has become the experimenter in all the fields of human endeavor. He has created a "Man's World" because he was "uncomfortable and at a disadvantage at home." "While the girls exhibit their advanced physical maturity and the greater abilities in cultural and social fields, where are the boys? A favored few, whose genes have clicked over a little faster, are maintaining a status on the field, court, or dance floor. A great number of the more downy lipped, the acne plagued, the falsetto voiced, have bent their knobby knees to science. That is man's stuff. As compared with the girls, these lads can at least hold their own in math, predominate in physics, and chemistry, and slice up their specimens without squealing." Because their sisters have outdistanced them in many factors, interesting and serious science education is needed for dignity.

There is prestige value with the older generation too. In this age of jive, when the doings of youth are viewed with no less than horror, it is comforting to think that "the dear lad had such a brilliant career in science ahead of him before" he received his "Greetings" from the Draft Board.

Fourth, continues the prestige principle with economic ramifications, it concerns itself with mastery of the common tools of living. It is a painful experience in money and a humble act of surrender to call the common artisan to the home for some minor repair. Our homes are fitted with things a bit too complicated for the average to set in order but imperfect enough so that the services of the craftsman, a common man with a bit of special training, is needed. "Can you imagine that fierce looking old boy in the daguerreotype being persuaded that he needed a new pump when he himself could cut a new leather valve from an old boot?"

Fifth, the general cultivation of perception, logic, and judgment, to restore saneness to our economy, requires science education. "The trash which floods our markets represents a prodigious waste of materials, fuel, labor, ingenuity and nervous energy. . . . Commerce has always had its medicine men, but they came to town but once a year. Now they have moved in on both sides of Main Street, and having crowded out everything else, are overflowing to the outskirts of town again where the sheriff used to keep them."

Sixth, "military preparedness and effectiveness depend on the scientific skills of not only the armorer back home but the poor guys up front."

Seventh, "our major industries must be staffed with persons of some knowledge of the sciences."

Eighth, we need science education for the scientist.

What are the factors which are in common to all objectives which will control success in these areas? We need to cultivate the art of observation. Alertness, speed, and accuracy in the powers of observation should be developed in the class room in every situation and by direct drilling. Ten or twenty years from now, the world of your students will have new facts. There is no anticipation of the facts but the students can be prepared to look at the new situation with practiced eyes. "They will recognize the familiar, register the new, and be prepared for action while the untrained are still blinking."

We must provide training "in ability and habit of making sense of what is seen." In this there are many elements. The simplest is cause and effect. Beyond this simple relationship there is a web of multiple systems to be untangled, keeping in mind their "interactions and various degrees of freedom." We must provide "training in the appreciation of qualitative factors and methods of identification. . . . Without such deliberately developed attunement of the discriminatory senses we make the dual mistake of over-generalizing on the one hand, and failing to note similarities on the other."

There is a fourth element in this general phase of training, "the development of acuteness and astuteness in quantitative affairs." Mathematics is failing in its potential. It has the lowest retention rate and yet "the habits of recognizing the significance, proportionalities, and calculable relationships of things are essential to perspective and understanding in any field."

This interpretative phase of science education must be combined into the skill of coordinated perception. Training in the recognition and attention of each factor and the merger and the joint maneuvers of these factors must be wed into the habit of doing something with the knowledges thus acquired. This is a problem for the educators for creativeness cannot be taught except by a creator. In this paragraph is the premise of the progressive school but in attention to the wedding, the first two factors may have been neglected.

A part of this third phase is in techniques. Anticipation, efficiency, second-hand knowledge, cumulative experience, and properly made records are the things that count. "Teach the methods and let the subject matter fall where it may." Leave the text books on the shelf for the first two months and devote that time previewing the course, its history, the key principles, relationships with other fields, and drill. Drill by demonstration, by games, and by problems in which the abilities to observe, to coordinate and see perspectives, and to find success in original accomplishment are the end. Then use the text books and find the ease with which you can breeze through the work ahead.

"Let's be realistic. What percentage of the subject matter will be remembered anyway, and if remembered be put to any satisfying use. It's a real percentage, but almost so small as to be considered in the special case category." Why give so much material to all when those who will have real careers in science can get the material in ten minutes at a later date when they need it?

The day is past when the science graduate gives the answers, just like that, to the questions put to him. More is needed than the factual information that he will get in his college and graduate studies, and in on-the-job experience. If one is to go high, there must be a broad and sound base on which to build. This broad

and sound base is only acquired "in the general habits of seeing, thinking, and working along the lines" suggested above. On the other hand, for those who are not to go high in the field of science, why provide instruments for celestial navigation?

The "three skills of analysis, coordination, and positive accomplishment should be the objectives of all science courses no matter what the subject matter and no matter whom the student."

Up to now, I have only tried to alert you for my message. "Do you really know your place in history?" You are at the apex of two great movements in civilization and human progress. On you rests the responsibility to build a broad base of intelligence for the common welfare. On you rests the philosophy of life. "We would be better off at this point to freeze scientific and technological factual knowledge at its present level, if by so doing we could divert the skills and energies of those normally engaged in such activities to the broadening of mass intelligence."

". . . Where else will citizens acquire the skills of observation, perspective, and accomplishment? Who else will orient the thinking of common man. . . . Who else will teach the habits of discrimination?" than you, the science teachers.

"Ladies and Gentlemen, the old temples are crumbling down. The palaces are now museums. The forum is now a burlesque hall, the art shrine (is) in the hands of the concessioneer, and the board room (is) given over to the advertising department. The cloistered courts of learning are now curb-service snack bars for indigestible specialities. The old institutions have lost their authority by default, folly, and general inadequacy. Most important, they never were built on a broad enough base of general human experience.

"Science has provided wonderful materials and ingenious tricks for assembly of a new edifice. It can be built as high as man aspires, and as broad as mankind needs. It can provide for expansion and adaption. It can build in inspirational beauty, and at the same time complete functionality.

"I warn you, it will be the last temple ever built by mankind. If it is built on inadequate foundation, in fact on anything less than broad and deep mass support, it will never get very high or be very stable. If jerry-built, it will come tumbling down and carry humanity with it in the most tragic disaster of all. The pieces will serve then only for props for underground shelters in which the remnants of mankind will huddle until celestial fate overtakes them. This is it, folks. This is the last chance. We better give some thought to the blueprints."

EASTERN ASSOCIATION OF PHYSICS TEACHERS
ONE HUNDRED EIGHTY-SIXTH MEETING

Joint Meeting
with
NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS
and
THE NEW ENGLAND BIOLOGICAL ASSOCIATION

Boston College, Chestnut Hill, Mass.

Saturday, Dec. 13, 1952

9:45 A.M. Registration—Science Building

10:00 A.M. Greetings, Rev. Joseph R. N. Maxwell, S.J., President, Boston College

10:15 A.M. Biology, Chemistry, and Physics in the Medical Laboratory, Fr. T. E. McCarthy, Boston College

11:15 A.M. Panel Discussion: Judging High School Science Fairs
Mr. Ray Scott, Rindge Tech.
Mr. Malcolm Campbell, Dorchester High School for Boys
Mr. Elbert Weaver, Andover Academy

12:15 P.M. Luncheon

1:15 P.M. Tour of the Science Laboratories

1:45 P.M. "Ultrasonic Velocity and Absorption in Fluids," Mr. Frederick E. White, Department of Physics, Boston College

Only the second and the third items are of special interest to the teachers of physics and for that reason only these are reported.

Much of the material of the panel discussion was covered in the article in the December issue of SCHOOL SCIENCE AND MATHEMATICS. It is not further reported.

The paper by Mr. F. E. White is reported in full.

ULTRASONIC VELOCITY AND ABSORPTION IN FLUIDS

FREDERICK E. WHITE, *Department of Physics, Boston College*

Since acoustics is a subject which is rather generally somewhat neglected both in high school physics courses and in elementary courses in colleges, it seemed rather fitting to speak on some aspect of it to this group, especially in view of the rapidly increasing importance of acoustics both to industry and to government. The Sunday newspapers and the popular magazines carry articles on such subjects as the reduction of the smoke nuisance by ultrasonic precipitators; the mapping of the floor of the ocean by echo sounding; the making of odd shaped holes in hard materials, using an ultrasonic drill which never touches the material; and the destruction of bacteria by using ultrasonic vibrations.

This paper is concerned with rather more fundamental considerations, namely, the velocity and absorption of sound in fluids at ultrasonic frequencies. The primary reason for the study of this topic is that it affords a means of gaining valuable insight into the structure of molecules.

Ultrasonics might be defined as that part of acoustics which is concerned with frequencies above the audible limit, which is in the vicinity of 15,000 cycles/sec. Although the fundamental phenomena on which the generation of ultrasonic waves depends had been discovered much earlier—the magnetostrictive effect, or the fact that the length of a ferromagnetic rod will change when the rod is put into a magnetic field, had been discovered by Joule in 1847, and the piezoelectric effect, or the fact that certain crystals will develop an electric charge when subjected to mechanical compression or tension, had been discovered by the Curies in 1880—it was only with the work of Langevin in 1917 that the science of ultrasonics really got started. Langevin was confronted with the problem of combating the submarine menace. Even though his work was completed too late to be of assistance in World War I, it resulted in the construction of both piezoelectric and magnetostrictive sources capable of sending out high intensity beams of ultrasonic radiation.

Of especial interest to the present discussion is the fact that in 1925 G. W. Pierce found that the velocity of sound in carbon dioxide gas varied with the frequency of the sound, being 258.8 m/sec at 42 kc/sec and 260.2 m/sec at 206 kc/sec. This was a momentous discovery since it indicated that a new phenomenon was entering the picture. According to the classical theory the velocity of sound in a gas is equal to $(\gamma P/\zeta)^{1/2}$ and is thereby independent of the frequency. The object of this talk will be to discuss some of the consequences of the study resulting from the unexplained results of Pierce's experiments.

Since one can argue in a qualitative fashion that an increase in velocity means an extra heating of the gas and thereby a transfer of energy from the wave to the gas, one would expect that corresponding to an increase in velocity one would also have an increase in the absorption of sound by the medium. For this reason we shall consider velocity and absorption together and will describe briefly some of the experimental means of determining either or both of these quantities. As a by-product it will be seen that acoustics can not be studied as an

isolated subject. In discussing only these few experimental methods we will have to bring in mechanics, heat, electronics, and optics, and a more profound investigation would have to include hydrodynamics, quantum mechanics, and physical chemistry.

The first method discussed will be one devised to measure absorption in liquids. The basic idea is that if an object is placed in a liquid it will have an extra pressure exerted on it when the sound is turned on. Fig. 1 shows the arrangement used by one experimenter, E. Hsu.[1] In the container C filled with the liquid

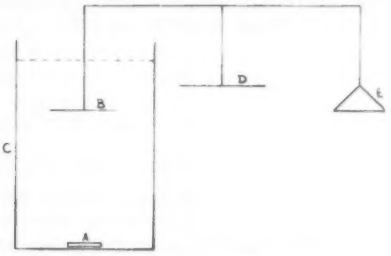


FIG. 1. Balance method.

being studied there is a crystal A which is the source of the ultrasonic vibrations, and, parallel to the crystal, a plate B which serves as one pan of a sensitive balance D. With no sound field the weight on the pan E is adjusted for equilibrium. The decrease in the amount of weight on E necessary to restore equilibrium when the sound field is on is a measure of the intensity of the sound. By changing the distance from the crystal to the plate one can determine the intensity absorption coefficient, 2α, which is defined by the relation

$$I = I_0 e^{-2\alpha x},$$

I_0 being the intensity at $x=0$, and I the intensity at $x=x$. For example, if the loss was m_1 at $x=x_1$ and m_2 at $x=x_2$, then, after dividing,

$$m_1/m_2 = e^{-2\alpha(x_1-x_2)},$$

and 2α may be easily computed.

This method is subject to quite a few difficulties, such as surface tension, reflection, cavitation, divergence of the sound beam, and hydrodynamic flow. It is considered that real trustworthy measurements can be made only for frequencies above 10 mc/sec.

Quite a different method which may be used for both velocity and absorption measurements in liquids was devised in 1932 independently by Debye and Sears in this country and by Lucas and Biquard in France. Known as the ultrasonic light diffraction method it is based on the idea that if a parallel beam of light traverses a beam of sound which is at right angles to the light, the sound beam will act as a diffraction grating. In Fig. 2, the light given off by the source A is made parallel by the lens-slit system, passes through the tank B which contains the liquid, and is focussed on the screen C. In the absence of any sound field a single image results, but when the sound source D is activated a diffraction pattern results. For the first order spectrum, one has

$$\sin \alpha = \lambda_l/\lambda_s,$$

where α is the diffraction angle, and λ_l and λ_s are the wavelengths of the light and sound waves respectively. By measuring α and knowing λ_l, one can determine λ_s. This, together with the known frequency of the sound source, will enable one to determine the velocity of sound.

This same apparatus may be used to determine absorption coefficients. The

[1] E. Hsu, *J. Acoust. Soc. Am.*, 17, 127 (1945).

idea in this case is that the greater the intensity of the sound beam the more the light is diffracted away from the central maximum. In applying this Biquard let the light in the main beam fall on a photocell and found the variation in intensity as the light beam was passed through the liquid at different distances from the sound source. More recently Burton, taking account of the tremendous

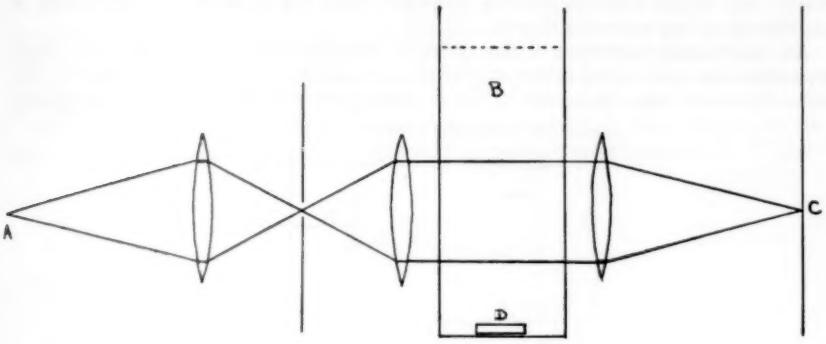


FIG. 2. Ultrasonic light diffraction method.

amplification of the secondary multiplier phototube, has measured the intensity of the first order diffracted light using a narrow light beam and a low acoustic intensity.

The velocity measurements made by this method are considered to be very reliable, but only the more recent measurements of absorption may be depended upon and those only in the region above 4 mc/sec.

The apparatus used by G. W. Pierce to get the results for carbon dioxide which were mentioned previously is known as an acoustic interferometer. If a reflector *R* (cf. Fig. 3) is made parallel to a vibrating crystal *C* and moved until

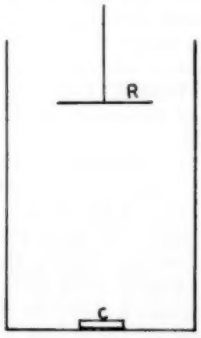


FIG. 3. Acoustic interferometer.

standing waves are set up, this fact can be observed by watching a plate current meter in the output stage of the driving oscillator. The distance between successive maxima will be half a wavelength. Knowing the frequency at which the crystal is vibrating, one can calculate the velocity of sound in the medium in question.

For absorption measurements using the ultrasonic interferometer one makes use of the idea that the farther away the reflector the less intense will be the returning wave, and hence the less effect it will have on the crystal. By measuring the current at two successive maxima one can compute the absorption coefficient.

The acoustic interferometer is of fundamental importance in the measurement of velocity in both liquids and gases and has been used a great deal for absorption measurements in gases and to a lesser extent in liquids. There are, of course, difficulties, among them being the problem of getting correct alignment of the crystal and the reflector, and the deviation of the sound beam from a plane wave. One might state in general, however, that the acoustic interferometer is capable of giving accurate results.

An interesting variation of the acoustic interferometer is the use of a fixed separation of source and reflector and the measurement of the amplitude of the wave by a hot wire. As is seen in Fig. 4, one essentially turns the interferometer

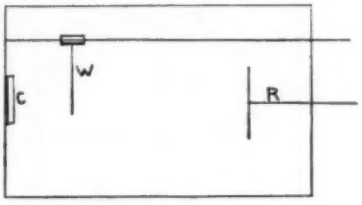


FIG. 4. Hot wire method.

on its side and introduces the hot wire *W*. Moving the hot wire along, one gets a series of minima and maxima as the resistance of the wire changes with the velocity of the medium. The spacing gives the velocity and the successive magnitudes the absorption coefficient. Very reliable results both for velocities and for absorption coefficients have been obtained for vapors, using frequencies from about 60 to 700 kc/sec, by Matta and Richardson.[2]

One of the most satisfactory methods for absorption measurements in both gases and liquids at comparatively low frequencies—for liquids, from about 24 kc/sec to 1 mc/sec—is the reverberation method which was first used for gases as long ago as 1933 in connection with the study of room acoustics. A crystal attached to the container filled with the fluid being studied is set into oscillation. After a steady state is established the transmitter is shut off and the crystal acts as a receiver. Thus one can study the decaying of the sound. By suitable choices of the shape of the container and the thickness of its walls it is possible to make the energy transmitted through the walls negligible as compared with that absorbed in the fluid. Hence the study of the rate of decay will yield the absorption coefficient of the fluid.

The last method which will be considered is the pulse method. The experimental arrangement is similar to that of the interferometer but waves are sent out only during a very small fraction of the time. Due to the fact that there is a great deal more absorption of sound in gases than in liquids and that gases produce much less damping of the transmitter than do liquids, this method is much more suited for work with liquids than with gases. Among its advantages are the impossibility of the creation of standing waves and the great lessening of any errors due to localized heating caused by the energy being sent through the medium.

Using this method Pellam and Galt estimated an accuracy of 0.1% for velocity measurements in liquids and an average of 5% for absorption measurements. This latter is much better than that given by other methods. The frequency range is from about 1 mc/sec up to, at present, 280 mc/sec, this latter frequency having been used by R. A. Rapuano. It should also be remarked that the pulse technique affords the principal method of measurement in solids.

Turning our attention to results and to their interpretation, we shall be very selective in the choice of material including only sample data which either illustrate very fundamental phenomena or which are particularly interesting in

[2] K. Matta and E. G. Richardson, *J. Acoust. Soc. Am.*, 23, 58 (1951).

themselves. No attempt at comprehensiveness will be made, and, furthermore, the interpretations will be rather superficial.

Boyer[3] has found a variation of the velocity of sound in argon gas at 0°C when the pressure is varied from 0.22 to 78.4 cm of mercury. The velocity is practically constant down to about 3 cm of mercury and then increases rapidly as the pressure is decreased further, showing an increase of 27% at the lowest pressure over the value at standard conditions. Classically the prediction is that the velocity sholud be constant. The explanation offered for the variation is that the classical theory breaks down when the average distance between molecules and the wavelength of the sound are of the same order of magnitude.

The situation becomes somewhat more complicated when, instead of a monatomic gas, one considers a diatomic gas. Fig. 5, taken from an article by Thaler,[4]

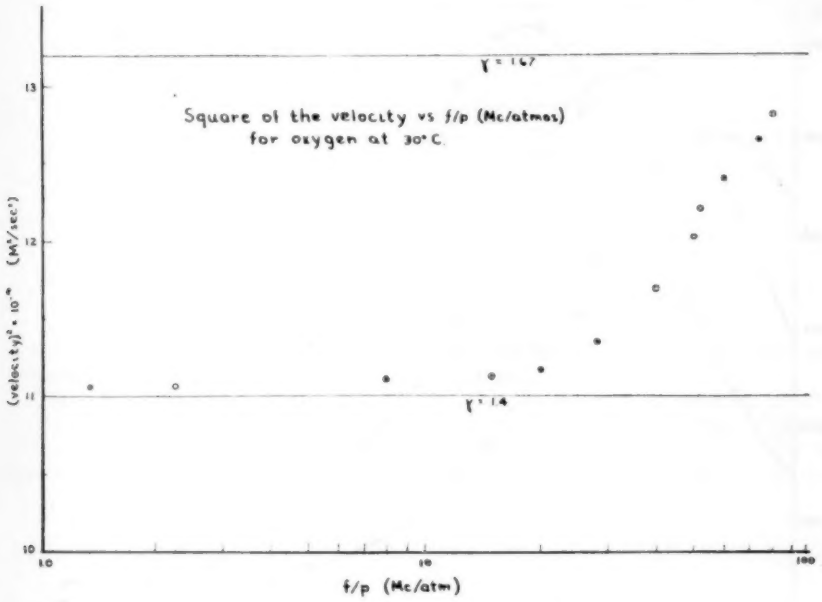


FIG. 5

shows how the velocity in oxygen increases with the ratio of the frequency and the pressure. The basic idea put forward to explain this is that the gas is made up of molecules which have both external degrees of freedom—the energy of translation which causes the pressure of the gas on its container—and internal degrees of freedom—the vibrational energy due to the parts of the molecules, the atoms, vibrating like dumbbells, and the rotational energy, due to the atoms rotating about one another. The postulate is advanced that the energy of the sound wave takes considerably more time to get transferred to the internal degrees of freedom than to the external ones, and if the frequency is high enough will never get into the internal motion. Thus for low frequencies oxygen will act like a diatomic gas ($\gamma = 1.4$), but at sufficiently high frequencies will act like a monatomic gas ($\gamma = 1.67$). Fig. 5 verifies this hypothesis quite adequately.

In the case of liquids the situation is quite different. Although from time to time it has been announced that dispersion—as the variation of velocity with frequency is called—has been found in certain liquids, the most recent evidence

[3] R. A. Boyer, *J. Acoust. Soc. Am.*, 23, 177 (1951).
[4] W. J. Thaler, *J. Acoust. Soc. Am.*, 24, 15 (1952).

indicates that the variation is probably due to experimental difficulties. A recent experiment by Barthel and Nolle[5] showed that in the frequency range 5–25 mc/sec the dispersion was not greater than 8 parts in 100,000, the limit of their experimental error, for all the liquids studied, which included water, isobutyl alcohol, sucrose solutions, sodium chloride, magnesium sulphate, and many others.

As long ago as 1845 Stokes developed an equation by means of which one can calculate the absorption due to viscosity and to heat conduction of a sound wave in a fluid. He showed that the ratio of the absorption coefficient and the square of the frequency should be a constant. In the case of monatomic gases experiment not only verifies this general relation but is in good agreement with the value of the constant.

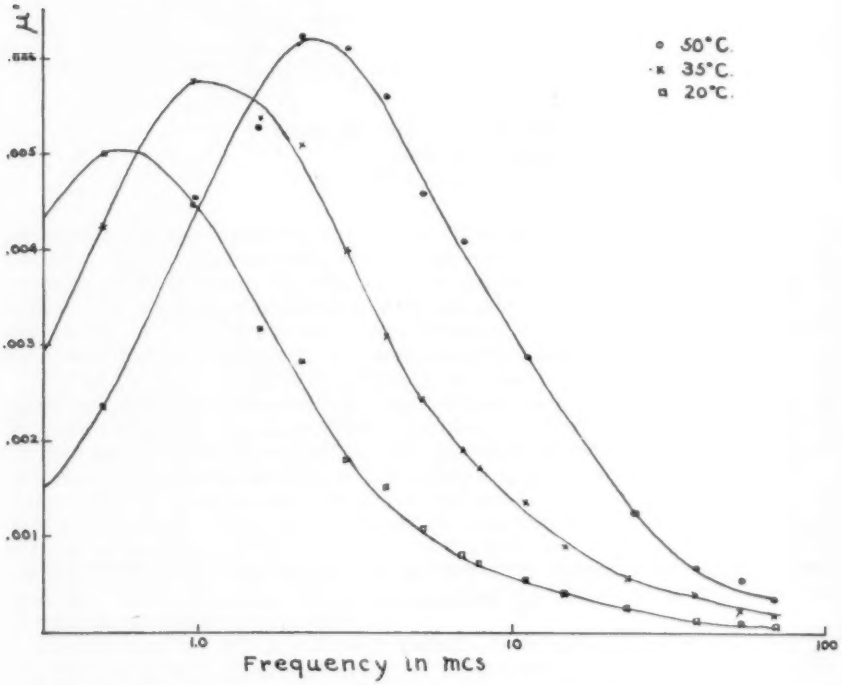


FIG. 6. Excess absorption per unit wavelength vs. frequency for acetic acid.

For diatomic gases we recall that there is dispersion and hence one would expect an excess amount of absorption in the dispersive region. This excess absorption is known as the molecular absorption. Some recent results[6] for dry air indicate that the ratio of the experimental value and the classical value of the absorption coefficient varies from about 2.4 at 30 Mc/atmos to about 1.3 at 100 Mc/atmos. Even though there is considerable scattering of the experimental points, the inadequacy of the classical theory and the need for the idea of molecular absorption are evident.

For monatomic or diatomic liquids such as mercury and liquid oxygen, Stokes' equation seems to be valid. For water the situation is somewhat different. The ratio of the absorption coefficient and the square of the frequency is a constant as is required by Stokes' equation, but the experimental value of the constant is

[5] R. Barthel and A. W. Nolle, *J. Acoust. Soc. Am.*, 24, 8 (1952).
[6] Ener, Gabrysh, and Hubbard, *J. Acoust. Soc. Am.*, 24, 474 (1952).

about $3\frac{1}{2}$ times the theoretical value. Various attempts have been made to explain the discrepancy, including a promising one by Hall who attributed the effect to

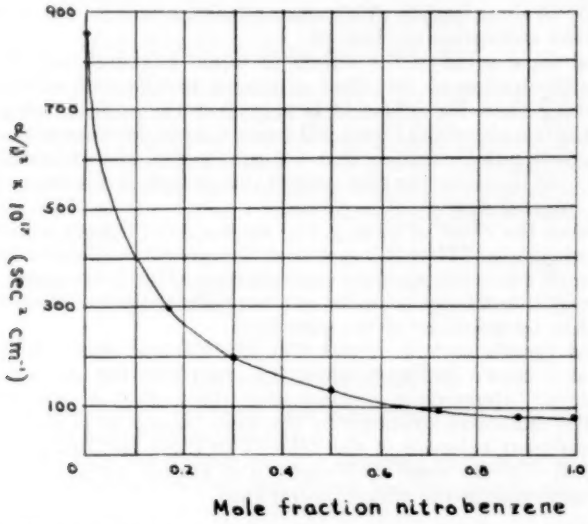


FIG. 7. Absorption in benzene-nitrobenzene mixtures at 25°C.

a structural rearrangement of the water molecules. However, at present, no completely satisfactory theory has been advanced.

One is strongly tempted to try to explain the discrepancy in water by postulating a mechanism similar to that which has been described in the case of gases, the so-called relaxation process. This turns out to be completely unsuccessful in water but has been fruitful for some other liquids. Fig. 6 shows some results for

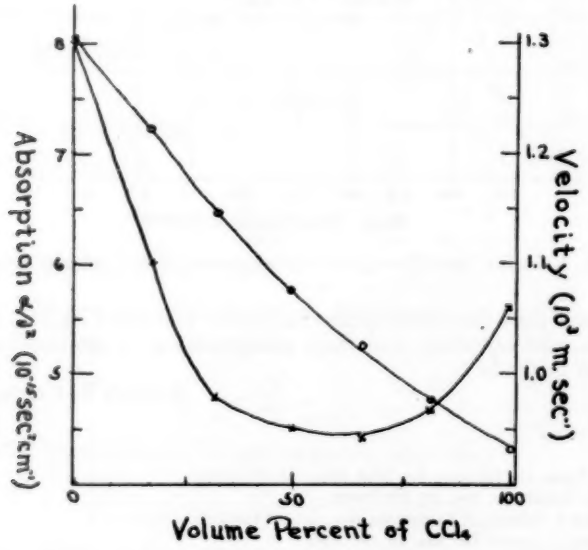


FIG. 8. Velocity and absorption in benzene-carbon tetrachloride mixtures.

acetic acid.[7] The fact that the curves go through a maximum is typical of what is expected in a relaxation process. One should also note that the frequency at which the maximum occurs increases with the temperature. It is hoped that further study of those liquids which show relaxation will lead to a better understanding of the absorption mechanism.

As a final topic some of the effects in liquid mixtures will be considered. Fig. 7 is an illustration of the effect of mixing two liquids[8] when one is much more absorbing than the other. It is seen that the addition of a very small amount of the less absorbing liquid will cause a rapid decrease in the absorption. The explanation put forward is that the presence of the molecules of the less absorbing liquid increases the efficiency of the process of distributing the energy among the internal degrees of freedom.

Fig. 8 shows the effect of mixing two unassociated liquids whose absorption coefficients are similar.[9] Here it is seen that the experimental curve for absorption has a minimum at an intermediate concentration. This is explained on the basis that the energy interchange is carried out more efficiently by collisions of different molecules than by molecules of the same kind.

Associated liquids such as water and the alcohols show quite a different behavior[10] as is shown in Fig. 9, where it is seen that the absorption reaches a maximum at an intermediate concentration. This effect is ascribed to the distortion of the molecular structure by the sound wave. It is also interesting to notice the different behavior of the velocity in these last two cases, decreasing almost linearly in the case of benzene and carbon tetrachloride and going through a maximum in the ethanol-water case.

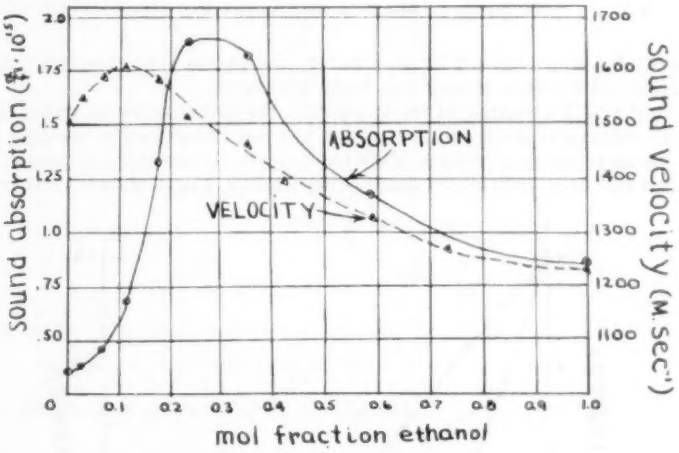


FIG. 9. Velocity and absorption measurements in water-ethanol mixtures.

It is hoped that this presentation has given you some idea of the methods used, the results obtained, and their interpretation, in the field of ultrasonic propagation in fluids.

ALBERT R. CLISH, *Secretary*

---

[7] Markham, Beyer, and Lindsay, *Rev. Mod. Phys.*, 23, 353 (1951).
[8] D. Sette, *J. Acoust. Soc. Am.*, 23, 359 (1951).
[9] Y. Wada and S. Shimbo, *J. Acoust. Soc. Am.*, 24, 199 (1952).
[10] C. J. Burton, *J. Acoust. Soc. Am.*, 20, 186 (1948).

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

Late Solutions

2338. *Rex Wood, Wlmore, Mich.; Seymour Samet, Chicago; R. H. Godard, Oregon State College.*

2336. *Charles McCracken, Jr., Cincinnati.*

2329, 33, 4, 6, 8. *Charles W. Trigg, Los Angeles.*

2336, 9. *Roy Wild, University of Idaho.*

A Late Solution

2340. *Proposed by Hugo Brandt, Chicago.*

Show that the summation

$$\sum_{n=a}^{\infty} \frac{1}{n^2},$$

for a sufficiently large is $(1/a)+(1/2a^2)$.

Solution by Julian H. Braun, Washington, D. C.

The required sum can be written in the form

$$\sum_{n=a}^{\infty} \frac{1}{n^2} = \sum_{j=0}^{\infty} \frac{1}{(a+j)^2}.$$

For a sufficiently large, $1/(a+j)^2$ is approximately equal to

$$\frac{1}{2}\left[\frac{1}{(a+j-1)(a+j)} + \frac{1}{(a+j)(a+j+1)}\right].$$

The summation of this approximation can be obtained exactly by use of the identity,

$$\frac{1}{a(a+1)}=\frac{1}{a}-\frac{1}{a+1}:$$

$$\sum_{j=0}^{\infty}\frac{1}{2}\left[\frac{1}{(a+j-1)(a+j)}+\frac{1}{(a+j)(a+j+1)}\right]=\frac{1}{2}\left[\frac{1}{a-1}+\frac{1}{a}\right]$$

$$=\frac{1}{a}+\frac{1}{2a^2}+\frac{1}{2a^3}+\cdots.$$

Hence, ignoring all terms after the second, we have for the value of the required sum the approximation $(1/a)+(1/2a^2)$ for a sufficiently large.

Using the fact that the true sum for $a=1$ is $\pi^2/6$ it will be found that the error in the approximation for $a=10$ is only .16%, and at $a=20$ the error is only .04%.

Roy Wild in his solution by use of the Euler-Maclaurin Summation formula derives the value:

$$\sum_{n=a}^{\infty}\frac{1}{n^2}=\frac{1}{a}+\frac{1}{2a^2}+\frac{1}{6a^3}-\frac{1}{30a^5}+\cdots.$$

2341. *Proposed by C. W. Trigg, Los Angeles City College.*

P is any point on the surface of the sphere inscribed in one of the five regular polyhedra (Plantonic Solids). Show that the sum of the squares of the distances from P to the vertices is constant.

Solution by Leon Bankoff, Los Angeles, Calif.

Except for the tetrahedron, the vertices of a Platonic solid are centrally symmetrical in pairs. Consider the plane passing through P and any pair of symmetrical vertices. On this section, P is a point on the circular section of the sphere and is connected to two other points, say vertices A and B of the solid, equidistant from and collinear with the center of the circle. By a familiar theorem, (see Altshiller-Court, College Geometry, 1925, page 13), if P is any point on the circumference of this circle, AP^2+BP^2 is constant. Similarly, the sum of the squares of the distances from P to the other symmetrical pairs of vertices is also constant, and hence their total sum is constant.

In the tetrahedron, we start with the centrally symmetrical extremities of the three bimedians. On the plane through P and the extremities of a bimedian, say J and K, PJ^2+PK^2 is constant. It follows that the sum of the squares of the distances from P to the midpoints of the six edges is constant.

We now consider the tetrahedron $D-ABC$ and the six triangles formed by joining P to each vertex. Applying Stewart's Theorem and collecting all known constant terms, we find that $PA^2+PB^2+PC^2+PD^2$ is constant.

It should be noted that the stated proposition is a special case of the more general theorem which does not restrict P to the surface of the inscribed sphere but which is valid for any sphere concentric with the polyhedron.

This problem is an extension of Problem 2295, SCHOOL SCIENCE AND MATHEMATICS, June 1952, wherein it was shown that the sum of the squares of the distances from P to the vertices of a regular tetrahedron is equal to $4(r^2+R^2)$, where r and R are the inradius and the circumradius respectively. In view of the foregoing discussion, we may state the general theorem that *if P is any point on the surface of a sphere concentric with a Platonic Solid the sum of the squares of the distances from P to the vertices is equal to $V(R_1^2+R^2)$, where V is the number of vertices, R the circumradius, and R_1 the radius of the sphere on which P lies.*

The proof of the analogous theorem in the plane may be found in John Casey, A Sequel to Euclid, Dublin, 1892, page 56.

The proposer also offered a solution.

2342. *Proposed by C. W. Trigg, Los Angeles City College.*

1. Find the three smallest consecutive even integers each of which is the sum of two squares greater than zero.

2. Show that no three consecutive odd integers can each be the sum of two squares greater than zero.

Solution by the Proposer

1. A number cannot be represented as the sum of two squares if it is of the form $4n+3$ or if among its factors there is a prime of the form $4n+3$ present to an odd power. Now in any set of three consecutive even integers there is one which is a multiple of 3. So if it is representable as the sum of two squares, it must also be divisible by 9. The only even multiples of 9 less than 165 which are equal to the sum of two squares are given in the following array:

16	18	20	*22*
70	72	74	*76*
88	90	*92*	
160	162	164	

Now 16 cannot be represented as the sum of two non-zero squares, and $22=2\cdot 11$, $70=2\cdot 5\cdot 7$, $76=2^2\cdot 19$, $88=2^3\cdot 11$ and $92=2^2\cdot 23$. But 7, 11, 19 and 23 are each of the form $4n+3$. Hence the smallest set sought is

$$160=4^2+12^2, \qquad 162=9^2+9^2, \qquad 164=8^2+10^2.$$

[The next larger set is $288=12^2+12^2$, $290=1+17^2=11^2+13^2$, $292=6^2+16^2$].

2. Every other odd integer is of the form $4k+3$, so no two consecutive odd integers can each be the sum of two squares, nor can three consecutive odd integers.

2343. *Proposed by Anna Jessop, Hayts Corners, N. Y.*

Prove

$$\sqrt{2}=\frac{4\cdot 36\cdot 100\cdot 196\cdot 324\cdot \cdots}{3\cdot 35\cdot 99\cdot 195\cdot 323\cdot \cdots}.$$

Solution by Leon Bankoff, Los Angeles

In the formula

$$\cos x=\left(1-\frac{4x^2}{\pi^2}\right)\left(1-\frac{4x^2}{3^2\pi^2}\right)\left(1-\frac{4x^2}{5^2\pi^2}\right)\cdots$$

we set $x=\pi/4$ and obtain

$$\frac{1}{\sqrt{2}}=\left(1-\frac{1}{2^2}\right)\left(1-\frac{1}{2^2\cdot 3^2}\right)\left(1-\frac{1}{2^2 5^2}\right)\left(1-\frac{1}{2^2 7^2}\right)\cdots$$
$$=\frac{3\cdot 35\cdot 99\cdot 195\cdot 323\cdot \cdots}{4\cdot 36\cdot 100\cdot 196\cdot 324\cdot \cdots}$$

Or,

$$\sqrt{2}=\frac{4\cdot 36\cdot 100\cdot 196\cdot 324\cdot \cdots}{3\cdot 35\cdot 99\cdot 195\cdot 323\cdot \cdots}.$$

The derivation of the formula

$$\cos x=\prod_{1}^{\infty}\left(1-\frac{4x^2}{(2r-1)^2\pi^2}\right)$$

may be found in

I. Todhunter, *Plane Trigonometry*, 1880, p. 261
E. W. Hobson, *Plane Trigonometry*, 1925, p. 346–348
S. L. Loney, *Plane Trigonometry*, 1896, p. 150

G. Chrystal, Textbook of Algebra, 1952, p. 352
H. S. Carslaw, *Plane Trigonometry*, 1948, p. 284

Solutions were also offered by A. R. Haynes, Tacoma, Wash.; Charles Salkind, Brooklyn.

2344. *Proposed by Georgia V. Rolison, Andover, N. Y.*

Solve $\tan\theta+\sec 2\theta=1$.

Solution by Mart E. Mitchell, Plainfield, Illinois

If we let $\theta=\alpha/z$ and replace $\tan\alpha/z$ by $\sin\alpha/(1+\cos\alpha)$ and simplify, we obtain
(1) $\cos^2\alpha-1-\cos\alpha\sin\alpha=0$ or
(2) $-\sin\alpha(\sin\alpha+\cos\alpha)=0$
From $\sin\alpha=0$, $\alpha=0$ or in general $\alpha=2\ \theta=k\cdot 0°$, k an integer.
Also from $\sin\alpha+\cos\alpha=0$, it follows that
(3) Tan $\alpha=-1$, and $\alpha=2\theta=3/4\pi\pm k\pi$, k an integer
Thus $\theta=67\frac{1}{2}°\pm k\cdot 90°$

Solutions were also offered by: Danill Pratt, Princeton, N. J.; Robert Glahn, Kirksville, Mo.; Leon Bankoff, Los Angeles; Robert A. Hunting, Janesville, Wis.; George R. Dixon, Ellenville, N. Y.; C. W. Trigg, Los Angeles City College; Margaret Joseph, Milwaukee; S. H. Highlander, Ashery Corners, N. Y.; Abraham Slaught, Benton Harbor, Mich.; Grace Hall, Valois, N. Y.; Hibbard Agard, Mecklenburg, N. Y.; Joanna M. Wilson, Covert, N. Y.; A. R. Haynes, Tacoma, Wash.; W. R. Trott, University, Miss., and the proposer.

2345. No solution has been offered. A. R. Haynes, Tacoma, Wash., writes that the problem is indeterminate.

2346. *Proposed by Leon Bankoff, Los Angeles, Calif.*

A realtor exchanged two square plots with integer sides and of different areas for one rectangular plot equal to the combined areas of the other two. He then subdivided the rectangular plot into eight square plots with integer sides, each of which was smaller than either of the two original square plots. What are the least possible dimensions of the plots, using one yard as a unit?

Solution by C. W. Trigg, Los Angeles City College

It is assumed that the eight square plots have equal areas, whereupon it is required to solve the equation,

$$x^2+y^2=8z^2=2w^2,$$

where w is even and $x\neq y\neq z$. This equation has the two-parameter solution

$$x=|\,m^2+2mn-n^2\,|,\qquad y=|\,m^2-2mn-n^2\,|,\qquad w=m^2+n^2,$$

where m and n are unequal, and both are odd or both are even.
The three smallest solutions are:

m	n	x	y	w	z
3	1	14	2	10	5
4	2	28	4	20	10
5	1	34	14	26	13

Hence the original plots were 34×34 and 14×14, each of the eight equal plots was 13×13 and the rectangular plot was either 13×104 or 26×52 with an area of 1352 square yards.
A solution was also offered by W. R. Smith, Pass-A-Grille Beach, Fla.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school

classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below.

2328. *David Gray, Angwin, Calif.*

PROBLEMS FOR SOLUTION

2359. *Proposed by Dwight L. Foster, Florida A&M.*

Find the equation to the two paraboles having their focus at any given point P of the conic $(x^2/a^2)+(y^2/b^2)=1$, and passing through the foci of the conic. Also show that the angle between the directrices is twice the eccentric angle of P.

2360. *Proposed by Ophelia Wrne, McDuffietown, N. Y.*

Solve

$$\sqrt{x+9}+\sqrt{x^2-9}=\sqrt{34}+4\sqrt{34}+4$$

2361. *Proposed by Alice Yello, Yonkers, N. Y.*

Solve for x, y, z:

$$a^2(y+z)=xyz$$
$$b^2(x+z)=xyz$$
$$c^2(x+y)=xyz$$

2362. *Proposed by Dwight L. Foster, Florida A&M.*

If

$$y=\arctan\frac{\sqrt{1+x^2}+\sqrt{1-x}}{\sqrt{1+x^2}-\sqrt{1-x^2}},$$

show that $x^2=xin\ 2y$.

2363. *Proposed by C. W. Trigg, Los Angeles City College.*

If A, B, C, D, represent the areas of the faces of a tetrahedron, with m their sum and N the sum of their six products two at a time, show that

$$2N\leqq(3/4)M^2<3N.$$

2364. *Proposed by B. B. Libby, San Francisco.*

Show that $\tan 3x \cot 2x$ cannot lie between 1/9 and 3/2.

CHINCHILLA "BULLS" SELL FOR $3,000

With mink out of style in Washington, the National Chinchilla Breeders of America moved into town with an estimated $500,000 worth of the aristocratic rodents.

Valued at about $1,000 to $1,500 each, the 450 chinchillas will be judged by the breeders in the two-day show for the best from the eastern United States.

Walter Little, assistant show chairman, said that $3,000 is the top price he knows has been paid for a chinchilla. These show animals are, in their field, the equivalent of prize, fabulous-priced bulls in stock shows, Mr. Little said.

A pair of ordinary chinchillas for breeding purposes cost only about $1,500, he said. There are about 400,000 chinchillas in the United States, Mr. Little added.

BOOKS AND PAMPHLETS RECEIVED

QUALITATIVE ANALYSIS AND ANALYTICAL CHEMICAL SEPARATIONS, by Philip W. West, Ph.D., *Professor of Chemistry, Louisiana State University;* Maurice M. Vick, Ph.D., *Associate Professor of Chemistry, Louisiana State University;* and Arthur L. LeRosen, Ph.D., *Late Associate Professor of Chemistry, Louisiana State University.* Cloth. Pages xii+223. 13.5×21 cm. 1953. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $3.75.

NUMERICAL SOLUTION OF DIFFERENTIAL EQUATIONS, by William Edmund Milne, Ph.D., D.Sc., *Professor of Mathematics, Oregon State College.* Cloth. Pages xi+275. 14.5×23 cm. 1953. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $6.50.

BUILDING HEALTH, by Dorothea M. Williams, *Cole Junior High School, Denver, Colorado.* Cloth. Pages xi+431. 16×22.5 cm. 1952. J. B. Lippincott Company, 333 Lake Street, Chicago 6, Ill.

ENJOYING HEALTH, by Evelyn G. Jones, *Special Teacher in Department of Instruction, Denver Public Schools.* Cloth. Pages xi+434. 16×22 cm. 1952. J. B. Lippincott Company, 333 Lake Street, Chicago 6, Ill.

COLLEGE ALGEBRA AND PLANE TRIGONOMETRY, by James H. Zant, *Oklahoma Agricultural and Mechanical College.* Cloth. Pages x+337+82. 15.5×23 cm. 1953. Ginn and Company, Statler Building, Boston 17, Mass. Price $4.00.

CHEMISTRY, A COURSE FOR HIGH SCHOOLS, Third Edition by John C. Hogg, *Chairman, Science Department and Harlan Page Amen Professor, The Phillips Exeter Academy, Exeter, New Hampshire;* Otis E. Alley, *Chairman, Science Department, Winchester High School, Winchester, Massachusetts;* and Charles L. Bickel, *Instructor in Science, The Phillips Exeter Academy, Exeter, New Hampshire.* Cloth. Pages xi+772. 14.5.×23 cm. 1953. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3, N. Y.

THE VIENNA CIRCLE, THE ORIGINS OF NEO-POSITIVISM, by Victor Kraft. Cloth. Pages xii+209. 13×21 cm. 1953. Philosophical Library, Inc., 15 East 40th Street, New York 16. N. Y. Price $3.75.

FROM LODESTONE TO GYRO-COMPASS, by Captain H. L. Hitchins, C.B.E., R.N. (Ret.), *Formerly Director, Compass Department, Admiralty,* and Commander W. E. May, R.N. Cloth. 219 pages. 12.5×18.5 cm. 1953. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $4.75.

WHAT MAKES THE WHEELS GO ROUND, New Revised Edition, by Edward G. Huey. Cloth. Pages viii+176. 13×20.5 cm. 1952. Harcourt, Brace and Company, 383 Madison Avenue, New York 17, N.Y. Price $3.00.

WAVES AND TIDES, by R. C. H. Russell, M.A., and Commander D. H. Macmillan, R.N.R. (Rtd.), F.R.I.C.S., *Assoc. I.N.A., Hydrographic Surveyor to the Southampton Harbour Board.* Cloth, 348 pages. 13.5×21 cm. 1953. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $6.00.

RESEARCH IN THE TRAINING OF TEACHERS, by Henry Bowers, M.A., D.Paed., *Principal, Normal School Stratford.* Cloth. Pages vii+167. 13×18.5 cm. 1952. J. M. Dent and Sons, 224 Bloor Street, West, Toronto 5, Ontario, Canada. Price $1.90.

THE SOVIET IMPACT ON SOCIETY, by Dagobert D. Runes, *University of Vienna.* Cloth. Pages xiii+202. 13.5×21.5 cm. 1953. Philosophical Library, 15 East 40th Street, New York 16, N. Y. Price $3.75.

LIVING THINGS, by Frederick L. Fitzpatrick, *Head of the Department of*

Teaching of Natural Sciences at Teachers College, Columbia University, New York, and Thomas D. Bain, *Teacher of Biology in the Harding High School, Marion, Ohio*. Cloth. Pages xiv+415. 17.5×25 cm. 1953. Henry Holt and Company, 383 Madison Avenue, New York 17, N. Y. Price $3.60.

ALGEBRA FOR COLLEGE STUDENTS, by Ross R. Middlemiss, *Professor of Mathematics, Washington University, St. Louis, Missouri*. Cloth. Pages ix+394. 14.5×23 cm. 1953. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. Price $3.75.

THE RADIO AMATEUR'S HANDBOOK, 30th Edition, by the Head-Quarters Staff of the American Radio Relay League. Paper. Pages 548+60+92. 16×24 cm. 1953. American Radio Relay League, Inc., West Hartford 7, Conn. Price $3.00.

FLATLAND. A ROMANCE OF MANY DIMENSIONS, by Edwin A. Abbott. Paper. 103 pages. 13×20.5 cm. 1952. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $1.00.

BLOOD PRINTS DISTINCTIVE AS HUMAN FINGERPRINTS

Existence of "blood prints" that are almost as distinctive as fingerprints was announced by the American Cancer Society.

The "blood prints" are electrophoretic blood patterns, that is, patterns of the migration of colloidal particles in blood plasma under the influence of an electric field.

Study of these patterns for hundreds of healthy and sick people shows a specific picture for each, Dr. Peter Bernfeld of Tufts Medical College finds.

The blood prints, unlike fingerprints, change a little from time to time, reflecting changes in health or a drastic change in diet, Dr. Bernfeld says.

Blood prints of identical twins are especially interesting to Dr. Bernfeld right now, and he will gladly run one for them if they go to his laboratory.

More than half those he has studied so far show striking similarity, though sickness, fever, nutrition and medicines make some differences.

ANXIOUS? HEART SLOWS DOWN, NOT SPEEDS UP

Anxiety causes a slow-down rather than a speed-up of the human heart rate. This finding, contrary to popular opinion, was announced by Drs. William N. Schoenfeld, Joseph M. Notterman and Philip J. Bersh of Columbia University psychology department.

The finding was made with a specially devised conditioned reflex test of 250 male students at Columbia. The research was done with support by the Air Force's School of Aviation Medicine, Randolph Field, Tex. The Air Force interest is said to come from concern that highly trained jet pilots could become physiologically handicapped, without being aware of it, because of their hearts' reaction to anxiety.

ERRATA

In the February issue, page 120, Table I in line 0 column 5 should read 43.5 in place of 45.5. Also in line 1 column 1 should read 73.0 in place of 75.0.

Snake-proof pants for sportsmen and others who must expose themselves to rattlesnakes and copperheads weigh just a little more than ordinary duck pants The snakeproof trousers are lined completely around the legs and above the knees with fine wire mesh padded with three layers of duck.

BOOK REVIEWS

INORGANIC CHEMISTRY, AN ADVANCED TEXTBOOK, by Therald Moeller, *Associate Professor of Chemistry, University of Illinois, Urbana, Illinois.* Cloth. Pages ix+966. 14.5×21 cm. 1952. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $10.00.

Inorganic Chemistry, an Advanced Textbook, is just that. This is not a beginning general chemistry text. The Author clearly makes that distinction in Chapter 1. General College Chemistry, in the final analysis, is a type of survey course which takes a brief look at all the branches of chemistry, including a little descriptive inorganic chemistry along with analytical, organic and physical chemistry. At one time the second semester of general college chemistry was mainly a descriptive study of the elements of the Periodic Table. Families of elements and their compounds were given a rather detailed study. More recently the second semester of general college chemistry has been devoted to elementary organic chemistry and an introduction to Qualitative Analysis. This change was made in order to teach something which puts greater emphasis on principles rather than on description and memory, and because it was felt that the organic and analytical would be more practical for the student who would never take more than one year of college chemistry.

Thus it has become necessary to add advanced courses in inorganic for the students who plan to specialize in chemistry. *Inorganic Chemistry* is a textbook for either seniors or beginning graduate students. In the preface Dr. Moeller states: "For a number of years, the University of Illinois has offered a one-semester course in advanced inorganic chemistry which surveys the field from a modern point of view and acquaints students with existing problems and current investigations. This course admits advanced undergraduate students and beginning graduate students."

Dr. Moeller further states in his introductory chapter: "Modern inorganic chemistry is more than a descriptive science. It attempts to relate the properties of chemical substances to their structures, which in turn are related to the ultimate structure of the particles which combined to make those substances. Modern inorganic chemistry employs, therefore, both the experimental and theoretical approaches and requires familiarity with each. It is concerned with all the elements and with all the combinations in which these elements are found." I feel that Dr. Moeller has written a textbook which meets the qualifications set up in the above quotation.

The book is divided into two parts:

I. Principles	(Pp. 1–372)
II. The Chemical Elements	(Pp. 373–410)

Under "Principles" the author treates the modern concepts concerning the structure of the atom, periodic classification of the elements, valency, complex ions, oxidation-reduction, and new concepts concerning acids and bases.

Part Two of this book gives a fairly complete treatise of an introductory nature on the elements of the periodic table. A chapter on the inert gaseous elements is followed by a chapter on hydrogen. The groups of the periodic table follow in this order: VII b, V b, IV b, III b, I, and II. The author concludes with chapters on the transition elements and the inner transition elements. Principles developed in Part One are used in accounting for properties of elements and their compounds as treated in Part Two.

The reviewer feels that the author has done an excellent job. Scattered information from many sources, much of which is recent, has been organized in an effective manner. All recent work is well documented.

The reviewer further feels that an excellent course for advanced students could be taught using this book as a guide. Furthermore, teachers of college chemistry should have this book on their desk as a ready reference.

GERALD OSBORN
Western Michigan College
Kalamazoo, Michigan

PRELUDE TO HISTORY, A STUDY OF HUMAN ORIGINS AND PALAEOLITHIC SAVAGERY, by Adrian Coates; Foreword by Glyn E. Daniel. Cloth. Pages xviii+289, Three Plates, 23 Text Illustrations and five maps. 15.2×22.2 cm. 1952. Philosophical Library, N. Y. Price $4.75.

The author divides history into: Modern Age of printed books; Pre-Modern Age of written records and the Prehistoric Age of oral tradition. He would further break the last Age into pre-savage and an in-between which is often referred to as the "Dawn of History." Men in this last category are sometimes called the "sackers of cities." This book is addressed to the third of the three Ages. It attempts, by synthesis and integration of what geology, anthropology, archaeology, palaeontology and psychology have to offer, to arrive at a sort of history that is more than oral tradition.

After an Introduction, which is chiefly concerned with a philosophy of history, there are ten chapters whose offerings are: Framework of Terrestrial Change; Evolution of Mankind; Primeval Savagery; two chapters on the Palaeolithic Age; Racial Groups; Palaeolithic Culture in the West; Primitive Mind; Primitive Society and Passing of the Hunting Economy. A concluding essay is on Palaeolithic Man and His Modern Successors. In the Foreword G. E. Daniel, Archaeologist of Cambridge University, England, says, "(This) book is by a non-professional archaeologist who has made it his business to keep thoroughly abreast in Palaeolithic archaeology. . . . He has, to my mind, written a readable, well informed and up-to-date general account of the subject." Hallam L. Movius Jr., Peabody Museum Harvard University, U. S. A. says, "Prelude to History can only be regarded as a semi-popular statement. . . . (Even) if not to be regarded as authoritative, (it) is a good thought-provoking book for amateurs."

The reviewer would heartily urge the reading of the Introduction, if no more, by both scientists and mathematicians.

B. CLIFFORD HENDRICKS,
457 24th Ave., Longview, Wash.

MATERIALS AND PROCESSES, by Max Kohn and Martin J. Starfield. Cloth. Pages 483, Figures 178. 14.6×21.6 cm. 1952. Macmillan Co., N. Y.

The Preface promises "the authors have presented a broad view of the technological industries by tracing the basic raw materials from their sources and through their processing to their ultimate use."

As one scans the book he is impressed by the frequent emergence of botanical, physical and chemical principles from both their involvements in processing and their repeated appearance in uses. So evident was this to the reviewer that he is prompted to characterize it as an excellent book for use in a course of "Motivated General Science."

The book's five principal divisions are captioned: Wood and Its Products; Fuels; Ceramics; Metals and Plastic Materials. The page distribution for these topics (in the order listed) is in the ratio of 5:4:3:10:2. Part four, on metals, offers four sub-sections titled: Iron and Steel; Nonferrous Metals; Fabrication, and Corrosion. "In the selection of content, the criterion has been the *materials engineering* point of view."

The authors are teachers. "This book was the outgrowth of many years of experience." The teaching view-point is evident in: The numerous, pertinent line drawings and photographic figures, each with ample, clarifying and arresting legend; Adequate thought provoking as well as memory refreshing questions and exercises; (Listing "Things to Do" after each chapter is unique and intriguing.) Appendices of Reference Books and Sources of Audio-visual Aids. There are six pages of double columned index which not only "keys" the text matter but also includes specific citations for illustrations and definitions.

In this reviewer's judgement, this book is thoroughly unique and has made a definite addition to resource materials for teaching the sciences. He would wish every teacher of science to have a copy at his or her elbow. He believes, if such

were the case, there would be no doubt of its frequent use to supplement and motivate many topics in the more formal science courses. It would also prove very helpful "to give the reader (perhaps some hesitant student) information which will help him choose his vocation."

B. CLIFFORD HENDRICKS

TEXTBOOK OF QUANTITATIVE INORGANIC ANALYSIS, Third Edition, by J. M. Kolthoff, *Professor of Analytical Chemistry, University of Minnesota*, and E. B. Sandell, *Professor of Analytical Chemistry, University of Minnesota*. Cloth. Pages xv+759. 15×23.5 cm. 1952. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $6.50.

This text provides practical work and theory for a course in elementary quantitative analysis and also for a course in advanced quantitative analysis. The theoretical basis for laboratory techniques is worked out in detail. A full description of apparatus and materials is given so that the thoughtful student can refer to the text and see for himself that the laboratory directions were wisely chosen. The text makes full use of the principles of physical chemistry as a basis for the methods and techniques employed. The student is given a firm foundation in the principles of chemistry, an understanding of phenomena observed during the course of analysis, and an understanding of the steps in analysis.

The problems are stated clearly and are directly related to the subject matter under discussion. Answers are given in most cases, which is believed to be highly desirable for the amateur analyst.

The chapter on separations in unusually complete and comprehensive. The treatment here given is excellent. The fundamental principles of each method of separation are adequately given and proper usage described. Separations based on organic reagents with their characteristics is very complete. Extraction methods, separations based on ion exchange and chromatography are described.

As the text is also intended for students in advanced quantitative analysis, laboratory directions are given for colorimetry and spectrophotometry. A description of analysis by Physical Methods, such as diffraction, turbidimetry, nephelometry, Raman spectra, etc., is given.

From a general point of view, it is believed that the text is excellent for students in elementary quantitative analysis provided that only very bright students are permitted to take the course. In so far as students in advanced quantitative analysis are concerned, it is believed that physics should be a prerequisite if this book is used as a text.

JAMES W. BOYNTON
Western Michigan College
Kalamazoo, Michigan

GENERAL BIOLOGY, Third Edition, Perry D. Strausbaugh, *Professor of Botany, Emeritus, West Virginia University* and Bernal R. Weimer, *Professor of Biology, Bethany College, West Virginia*. Pages viii+813. 1952. John Wiley and Sons, Inc. New York. Price $6.00.

The new edition of *General Biology* has many valuable changes which make it a more flexible text for the use of both the instructor and the student. Among the major changes in the text are the following: up-to-date discussion of enzymes, stress on the scientific method, logical planning of material, discussion of the origin of life and the theory of evolution, and new illustrations selected for their use as a teaching aid. The material is arranged for the current concept of teaching biology; namely, studying plants and animals as living things which perform the same life functions differing only in structure and in the nature of machinery by which they carry on their work. After each subject has been covered the two kingdoms are then surveyed separately.

The book is completely in keeping with new knowledge gained on such subjects as photosynthesis, enzymes, hormones, genetics and respiration. The major-

ity of the material is clearly stated and explained.

In the middle of the text appears a series of twenty, well done, colored plates concerned with many different phases of biology. This unusual position in the text may seem awkward to some readers.

NORMA ANN PETEFISH
Arlington Heights, Ill.

ALGEBRA FOR PROBLEM SOLVING, Book 1, by Julius Freilich, *Chairman, Mathematics Department, Brooklyn Technical High School, New York*, Simon L. Berman, *Chairman, Mathematics Department, Stuyvesant High School, New York*, and Elsie Parker Johnson, *Chairman, Oak Park and River Forest High School, Oak Park, Illinois*. Pages viii+568. 1952. Houghton Mifflin Company, New York, Price $2.88.

This book gives a thorough coverage of the material for a first course in high school algebra.

Mechanically the book is unusually attractive, of sturdy construction, and easy to read. Figures are exceptionally well drawn and the use of red print is an especially arresting feature. For example, red print is used to point out basic definitions, to set off illustrative examples, to call attention to things to remember, to indicate the negative numbers on a line, and in many other ways. In fact, one seldom finds such an interesting and effective use of red print.

The book is obviously the product of experienced teachers of mathematics who have put much study and labor into its preparation. One finds an abundance of applied problems and also enough exercises. Provision is made for individual differences by means of plateau sections for slower students, advanced problems for better students, and "extras for experts" in the nature of recreational materials. Test and review materials as well as some material on maintaining arithmetical skills are included all of which are good features. More material than most classes can cover is included which is helpful for busy teachers. The checking techniques are excellent.

To the reviewer it seems that rules are stated in "boxes" too soon and possibly before the students would have a chance to develop or make generalizations for themselves. Although the book as a whole has a number of modern and novel features, the definitions, rules, and terms are stated in a somewhat traditional form. For example, the word "cancellation," which seems to be disappearing from most of the newer algebra texts, is brought into focus; for, on page 338 one finds a paragraph entitled, "What cancellation is and how to use it."

Special mention should be made of several interesting historical sections entitled, "The Human Equation—Snapshots from Algebra's History." This information should prove quite valuable to any algebra teacher regardless of the text being used.

The book has an index but no preface. However, on the whole, it gives a pleasing impression and seems to be very teachable. In choosing a text this book merits careful consideration.

CLYDE T. MCCORMICK
Illinois State Normal University
Normal, Illinois

PRACTICAL AND EXPERIMENTAL GEOGRAPHY, by W. G. V. Balchin, *Lecturer in Geography, King's College, University of London* and A. W. Richards, *Senior Geography Master, The Grammar School, Farnborough, Hants*. Cloth. Pages viii+136. 21.5×17 cm. 1952. New York: John Wiley and Sons, Inc. Price $2.75.

This book presents over seventy drawings and plans for the teacher of geography wishing to construct working models for class use. Directions are clearly stated.

The book is divided into five sections: Section A. *The Earth's Movements and some Effects*, presents drawings for model tellurions, longitude-time wheels, sun-

dials, gnomons and the like. Section B. *Land Forms*, directions for models of land forms, general relief modelling etc. Section C. *The Atmosphere and the Oceans*, directions for the construction of meteorological instruments and models of wind roses, cold air drainage, the movement of planetary rain belts etc. Section D. *Survey and Map Projections*, directions for construction of simple survey instruments, working models to demonstrate perspective map projections etc. Section E. *Distribution Maps and Cartograms*, directions for statistical distribution on dot and isopleth maps, and the making of mathematical graphs, flow diagrams, clock graphs and the like.

VILLA B. SMITH
John Hay High School
Cleveland, Ohio

GEOGRAPHY OF LIVING THINGS, by M. S. Anderson, M. A. Cloth. Pages ix+202. 19×12.5 cm. 1952. Philosophical Library, New York. Price $2.75.

This volume deals with Biography which the author defines as "the study of the biological relations between man, considered as an animal, and the whole of his animate and inanimate physical environment." It is a thought provoking, timely study of some of our urgent modern problems. It is an interpretation of man's attempts to adapt the earth and its resources to his needs. Among problems discussed are those pertaining to food for the world's millions; the ever present threat of famine; soil and soil conservation; pests and diseases which attack man and his crops.

VILLA B. SMITH

AUTOMATIC GREENHOUSE USED IN INSECT RESEARCH

A greenhouse which automatically controls its own temperature and humidity and regulates partially solar radiation has been placed in operation at the University of California's Citrus Experiment Station to aid orchard insect studies.

First of its kind to be constructed, it is named the "biotrone," meaning "balance of life."

The biotrone is an insect-proof glass house equipped with automatically controlled heating and cooling units.

A set of aluminum louvers completely surrounds the house. These are operated by three solar thermostats, installed on top of the east, south and west sides of the structure. When the solar radiation reaches a given intensity, the thermostats automatically close the louvers to maintain their degree of warmth.

Temperatures can also be controlled in the greenhouse by a time clock, which is independent of the solar thermostats. Days of varying length can be simulated at any time of the year by use of tungsten filament and fluorescent lamps and the louvers.

Dr. Charles A. Fleschner, entomologist, will direct experiments in the biotrone. He has found that variation in the physiological conditions of plants has a striking effect on the reproduction rate of the mites feeding on the plants and on their natural enemies.

Experiments to be conducted will include studies on the effects of different varieties of host plants, soils, irrigation water, growth cycles, physical characteristics of the host-plants, and climate on the mite-predator complex.

Thermometer clamp for the laboratory fits over the edge of any beaker and holds the thermometer against the side of the vessel in an easy-to-read upright position. The thermometer can be slipped up or down through the clamp. The clamp also will hold glass stirring rods and metal electrodes.